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SOME PRACTICAL ASPECTS OF THE SURFACE CHEMISTRY OF GLASS

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PART I

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V. **Summary**

I. Introduction

The atomic structure of glass has been elucidated to an extent that it now can be used as a basis for understanding and explaining many of its properties. However, glass technologists and users of glass in its different forms, such as fibers, containers or as material for making mirrors or optical instruments, are still facing one difficulty; namely, the correlation of properties which depend chiefly on the glass surface with its structure. Realizing the need for a better understanding of the surface chemistry of glass, Glass Science has made an effort to develop methods for studying the properties and behavior of the glass surface.

The glass surface has a profound influence on many important properties. It is obvious that it is the surface that is affected when the glass is in contact with corrosive liquids or gases. The role which the surface plays in electric insulation is also well understood. But there are many more properties where the composition and structure of the glass surface has a decisive effect and where its role is not quite so obvious. Recently[1] we have explained the reasons why the mechanical strength, especially the failure of glass under loads of long duration, is affected by the glass surface and its reaction with the atmosphere.

It is the object of this lecture to point out the differences existing between the structures of the surface and of the bulk of the glass. A brief survey will be given of some methods which the scientist has at his command for exploring the nature of the surface layer. Furthermore, we shall discuss some practical problems connected with the manufacture and utilization of glass.

II. The Structure of the Glass Surface

Our present concept of the atomic structure of glasses is based to a great extent on X-ray diffraction patterns. In the last few years one has learned to interpret the diffuse halos which are obtained when X-rays are allowed to pass an amorphous substance. By Fourier analysis of these diffraction patterns, B. E. Warren and his school have succeeded in calculating the geometrical configuration of the atoms in simple glasses and their

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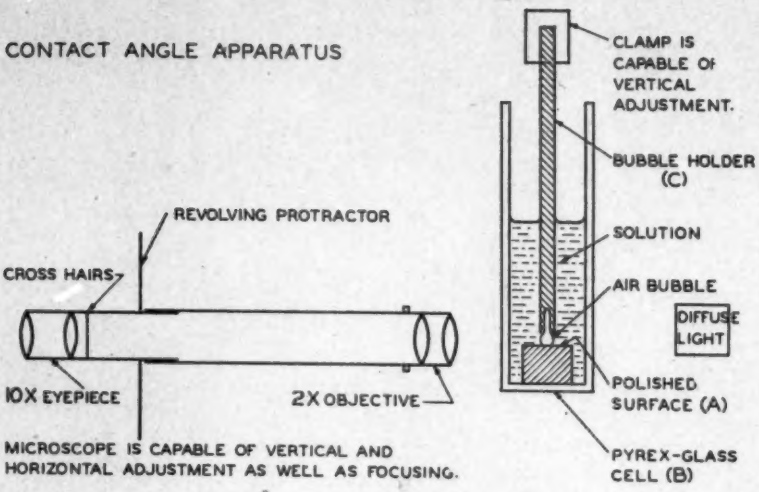


Fig. 1

average distances. We know that all silicates, crystalline or vitreous, have the SiO_4^{4-} tetrahedron as the characteristic building unit. This anionic group is formed by the silicon ion Si^{4+} surrounded by four oxygen ions. The configuration of the ions is the result of the attraction forces acting between the fourfold positively-charged silicon and the twofold negatively-charged oxygen ions, and of the repulsive forces which exist among the oxygen ions, having the same negative charge. As a result of these forces the oxygen ions are equally spaced around the silicon. They form the corners of a regular tetrahedron. The distance between the centers of two O^{2-} is 2.65 A.U. and that between each O^{2-} and the Si^{4+} is 1.6 A.U. Only if the silicon to oxygen ratio is 1:4, as in sodium or calcium orthosilicate, Na_4SiO_4 and Ca_2SiO_4, can independent SiO_4 tetrahedra form. These compounds form fluid melts and crystallize on cooling. If the ratio of Si:O is 1:3 or 1:2.3, as it is in commercial glasses, a part of the oxygen ions belongs to two tetrahedra. The sharing of oxygen ions between two silicon ions brings about a certain polymerization. Melts of this type do not readily form crystals but can be easily supercooled.

Fundamentally there is not a great deal of difference between an amorphous and a crystalline silicate. The ultimate constituents, cations and oxygen ions, have identical functions in both modifications. The principles of crystal chemistry can also be applied to a large extent to glasses. For example, the modern concept of the structure of glasses and crystals does not permit the talking about definite compounds, silicates or free silica being present. Just as in the case of crystalline sodium chloride where each Na^+ is surrounded by 6 Cl^- ions and vice versa, and where one cannot attribute a particular chlorine ion to a certain sodium ion and call this couple a molecule, so one cannot take two of the four surrounding oxygens and call them and the central silicon ion a silica molecule. Instead of discussing hypothetical compounds, one has to investigate the geometrical configuration which results from the attraction and repulsion forces effective between the ions. These forces, depending on the size, polarizability and the charge of the ions, are the principal factors which govern the glass structure.

One finds, for example, that the small cations with high positive charges, such as Si^{4+} and B^{3+}, are the ones which succeed in surrounding themselves with four oxygen ions, thus forming stable anionic complexes. Those cations which are weakly charged, or which are large, do not exert strong enough attraction forces to form their own groups. Ions like Na^+ and Ca^{2+} have to be satisfied with secondary positions in the interstices of the three-dimensional network. They, too, will be surrounded by oxygen ions, but their distance from the oxygen ions will be greater. The Na-O distance in a sodium silicate glass is approximately 2.3 A.U. as compared with 1.6 A.U. for the Si-O distance.

Based on their participation in the glass structure, it has been found convenient to distinguish between network-forming cations, such as silicon and boron, and network-modifying cations such as the alkalies and the alkaline earths. This classification corresponds to the earlier distinction between the glass-forming acids, such as SiO_2 on the one side, and on the other, the basic oxides which by themselves cannot form a glass.

The electric forces of the cations as the guide for their participation in the structure explain the relatively high mobility and reactivity of the monovalent ion Na^+, as compared with that of the highly charged Si^{4+}. At temperatures where the glass is rigid, the sodium ion can be replaced by other ions without materially changing the atomic pattern. The Na^+ also diffuses and migrates through a glass with relative ease if a concentration gradient or an electric field is established.

The configuration of the ions in the surface layer of a glass is not identical with that of the bulk. Breaking a piece of glass severs both weak and strong bonds. The free valence forces extending into space or, in the parlance of the crystal chemist, the incomplete coordination of the surface cations calls for a readjustment of the ions in the surface layer. One way to satisfy these forces is to attract water molecules or greasy impurities from the surrounding atmosphere. The water in this case is not merely adsorbed at the surface but combines chemically with the glass producing OH groups.

Another way to satisfy the strong field of the silicon and to reestablish its original fourfold coordination is to push those cations to the surface which are more easily satisfied with an incomplete coordination. From this point of view we must expect the alkalies and even the boron to go to the surface as soon as the temperature of the glass permits such an atomic rearrangement.

The behavior of alkali in glass can be compared with that of surface active ingredients in water. They migrate to the surface because they lower the free surface energy of the system. Because of the tendency of the system to keep its surface energy at a minimum, structure and composition of the surface layer of a glass will be different from the interior.

As compared with other glass constituents, the alkalies are characterized by a relatively high vapor pressure. Their volatilization is negligible only at low tempera-

tures. At 1000°C. or higher it is appreciable especially for glasses with high alkali content. A clean, fresh glass surface undergoes several unavoidable changes with time. Composition and temperature of the glass determine the importance of each factor and it may be convenient to distinguish three temperature ranges:

a) At room temperature or slightly elevated temperatures, the fresh glass surface attracts water and greasy impurities from the atmosphere. In contact with water, the surface of a silicate glass can be considered to be a silica gel containing Na^+, Ca^{2+} and other cations in a state of adsorption.

b) Around 1000°C. or higher, the volatility of the alkali of fluorides and other volatile constituents dominates the changes taking place in the glass surface.

c) In the intermediate range, let us say between 300°C. and 700°C., the composition and structure of the glass surface is affected by the migration to the surface of those constituents which lower the surface free energy.

This picture of the effect of temperature on the surface structure is a rather crude approximation of the conditions actually encountered because the latter depend so much on the composition of the glass and on the time. It is not possible, for example, to predict whether a glass at 800°C. increases its alkali concentration in the surface due to surface tension or rather decreases it due to its volatility. In this range both phenomena occur simultaneously and the balance, which depends on the composition of the glass and the atmosphere, has to be determined by one of the methods which shall be mentioned later. The lifetime of a glass surface which is "fresh and clean" is extremely short. Even in vacuo it is impossible to preserve a surface structure which could be called a cross-section through the interior of a glass. Little direct information is available on the nature of fresh glass surfaces. However, in the case of mica, the properties of fresh surfaces and their ageing have been studied. The free valence forces extending into space give rise to interesting electrical phenomena. Fracture is usually considered an irreversible process. However, if we could prevent the ageing of the fresh surfaces, the free valences could be used to join two pieces and restore their original strength. J. M. Macauley[2] and J. G. Strachan[3] in their work on the seizure and the ageing of surfaces describe some very interesting experiments along these lines. They found in the case of mica that over the range of Newton colors of thin films (5×10^{-6} to 2×10^{-4} cm.) the seizure forces vary inversely as the square of the distance between the surfaces. Extrapolating to molecular distances resulted in stresses of the order of the strength of glass. Experimentation with glasses is much more difficult than with the mineral mica, but the phenomena are very much the same for both silicates. The strong adhesion of glass dust on the freshly cut surface is well known and corresponds exactly to the recombination of freshly cleaved mica plates. The analytical chemist often takes advantage of the free valence forces obtainable by scratching the surface of his test tube in order to induce crystallization of a supersaturated solution. Scratching the inner wall of a test tube with a glass rod produces a rapid sequence of seizures and fractures. The free valences or the electric fields emanating from the surface ions attract other molecules. A substance, crystal or gas, in a state of supersaturation has the greatest probability of being adsorbed and forming nuclei which grow and release the supersaturation.

Besides these unavoidable changes of the fresh surface there are a large number of controllable changes which are obtained by exposing the glass surface to gases, vapors, liquids and solids.

For a discussion of the chemical changes occurring in a glass surface, it might be practical to divide them into several groups: 1) Molecular rearrangements due to surface and interfacial tension; 2) Volatility of glass constituents; 3) Base exchange reactions of the dry glass surface; 4) Dealkalization of the glass surface; 5) Reduction processes; 6) Deposition of metals and compounds on the glass surface: a) from the liquid phase, b) from the vapor phase; 7) Hydrolysis of the glass surface and reaction of the silica gel with aqueous solution and vapors.

Before further discussion of these changes of the surface and their relations to practical problems, I want to make you familiar with some of the methods and tools which helped us to learn more about the nature of glass surfaces and their reactions.

III. Methods for Studying the Properties of the Glass Surface

1) *Chemical Methods.* Most methods which are used for determining the behavior of a glass surface are chemical reactions between some reagent and the alkali of the glass. Widely used for determining the chemical resistivity of a glass is the treatment of its surface with water or with an acid leading to a replacement of sodium ions and calcium ions by hydroxonium (H_3O^+) or hydrogen ions. This reaction is strong if the glass surface contains much alkali and if the proportion of the silica and alumina is low. The progress of the reaction can be measured by determining analytically the amount of acid which is used to neutralize the basic oxides. Another method is based on the determination of the thickness of the "leached out" film by optical methods. Most methods accelerate the reaction by raising the tempera-

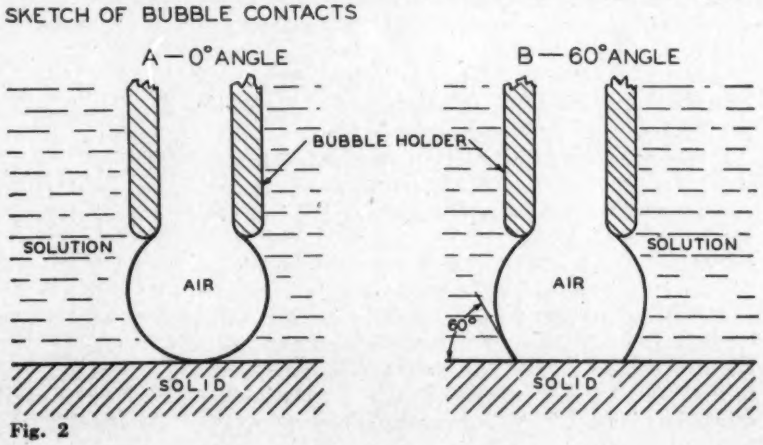


Fig. 2

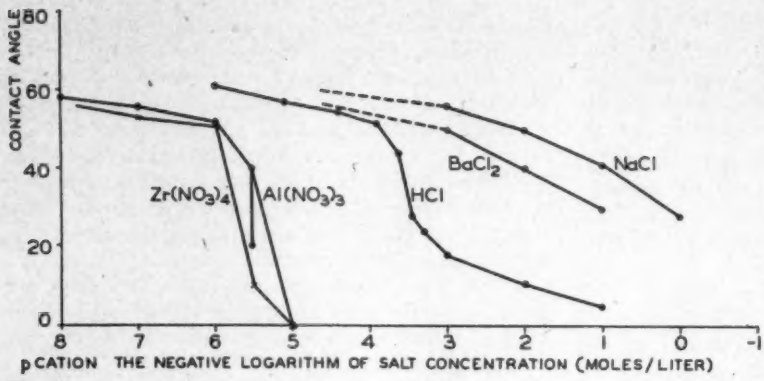


Fig. 3

ture, sometimes above the boiling point of water (autoclave test).

R. Weber[4] introduced a method by which the glass was exposed to the vapor of hydrochloric acid under conditions where the reaction product, NaCl, remained on the surface. The intensity of the film or the time required for producing a visible film of NaCl was used to judge the quality of the glass.

Another method developed by F. Mylius[5] allows the glass to react with an acidic dyestuff, iodoeosine, also under conditions where the reaction product has to remain at the surface. The dye itself represents an organic acid which is soluble in ether. The reaction product, sodium iodoeosinate, however, is insoluble in this solvent but can be dissolved in water and determined colorimetrically.

In an earlier paper, H. S. Williams and W. A. Weyl[6] described several methods for testing the alkalinity of a glass surface at elevated temperature by exposure of the glass surface to metal chloride vapors. Cuprous chloride, for example, enters a base exchange reaction and the amount of cuprous ions entering the glass is approximately proportional to the amount of alkali ions present. The concentration of the cuprous ions can then be estimated optically by changing the cuprous ions into metallic copper through reduction with hydrogen. This method is particularly suitable for those cases in which one wants to learn something about the distribution of the alkali in the glass surface, for example, if a part of the surface has been dealkalized. Similar reactions can be carried out with silver salts and with thallous salts, the latter producing fluorescence. If we are interested in reactions involving ions such as Ba^{2+}, Pb^{2+} and Al^{3+}, no similar method is available which makes the reaction directly visible. For these cases an indirect method has been developed using the contact angle of an air bubble pressed against the submerged glass surface.

2) *Contact Angle Measurements for Determining the Adsorption of Cations on the Glass Surface.* Base exchange reactions involving Ba^{2+}, Pb^{2+} or Al^{3+} ions cannot be easily followed by the characteristic chemical features of these ions. In order to extend our knowledge of these ions, H. H. Kellogg[7] worked out a method based on the use of an organic amine, lauryl trimethyl amine bromide, as an indicator. Traces of this compound when adsorbed at the surface will make the glass water repellent. The degree of adsorption of the lauryl trimethyl ammonium ion (L. T. M. A.) can be judged by the degree of water repellency; the latter can be quantitatively measured by observing the "contact angle."

From the various existing methods for measuring the contact angle at the glass-water-air interface, the "Captive Bubble" method was found to be the most suitable. This method has been used for studying the mechanism of mineral flotation. The apparatus which A. F. Taggart[8] and his collaborators developed for this purpose was used, but the projection camera was replaced by a low power microscope with a protractor eyepiece. Figure 1 shows the arrangement of the various parts.

The glass to be tested is placed in the pyrex glass cell which contains the test solution. The cell with contents is placed in a holder on a short optical bench. The bubble holder consists of a glass rod with a small section of glass tubing sealed to its lower end. The bubble holder is placed in a clamp which provides movement up and down as well as laterally. It is then immersed in the solution and a small air bubble, about 3.0 mm. in diameter, is formed on the hollow end of the bubble holder with the aid of a medicine dropper in the form of a J. The cell is illuminated by a diffuse illumination lamp. Observation of the bubble in the cell is made by a low power (20x) microscope capable of lateral and vertical adjustment. The microscope has a protractor eyepiece with crosshairs so that angles on the object may be measured.

To make a contact angle measurement, the bubble is first pressed down against the glass surface for 15-30 seconds and then is slowly raised. If the contact angle of the glass is zero, the bubble will leave the surface without any distortion (Figure 2A). If there is a finite angle, the bubble sticks to the surface and begins to elongate (Figure 2B). At the point where elongation begins, the raising of the bubble is stopped and the cell is tapped gently with the finger until the bubble no longer adjusts its angle. The angle at each side of the bubble is measured with the aid of the protractor eyepiece and crosshairs.

Inorganic ions when added alone do not affect the zero contact angle of a clean glass surface. If, however, the glass had been made water repellent by treating it with L. T. M. A., the contact angle will be affected by inorganic ions.

Table I and Figure 3 summarize the results of the displacement of L. T. M. A. ions from the glass surface by

TABLE I.

EFFECT OF DIFFERENT SALTS ON CONTACT ANGLE

Salt	P_{Cation} Causing Reduction from 60° to 40°
NaCl	0.9
$BaCl_2$	2.0
H Cl	3.6
$Al(NO_3)_3$	5.5
$Zr(NO_3)_4$	5.8

H^+, Na^+, Ba^{2+}, Al^{3+} and Zr^{4+}. In order to judge the relative effectiveness of each cation in its ability to displace

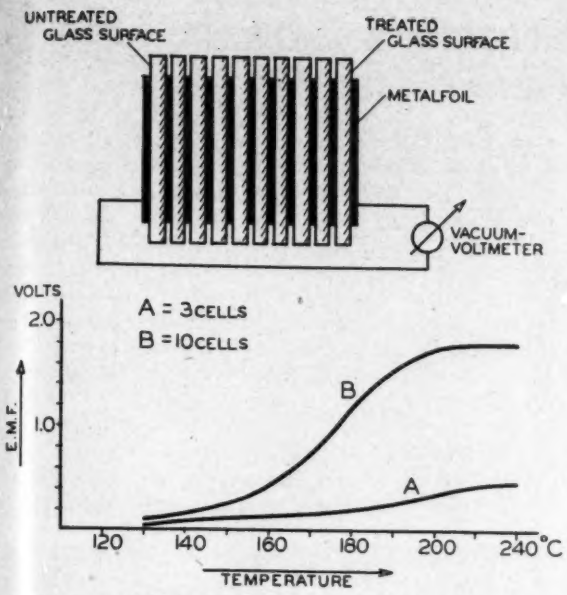


Fig. 4a top; 4b below.

the amine ion, the concentration of cation necessary to reduce the contact angle from the original 61° to 40° was chosen as the basis of comparison. The concentration is expressed as p_{cation}, the negative logarithm of the cation concentration in mols per liter.

The value 2.0 for Ba^{2+}, for example, shows that a concentration of 10^{-2} mols of Ba^{2+} is required for reducing the angle from the original 61° to 40°. The same can be accomplished by only $10^{-5.5}$ mols of Al^{3+} ions.

Comparing the relative adsorption of some univalent and divalent cations, H. H. Kellogg found that the order of adsorption, namely, for monovalent ions:

$$H^+ \text{ (probably as } H_3O^+) > K^+ > Na^+ > Li^+$$

for divalent ions: $Ba^{++} > Sr^{++} > Ca^{++} > Mg^{++}$ Ba^{2+} Sr^{2+} Ca^{2+} Mg^{2+} agreed with the order of the precipitating power of these ions towards negatively charged colloids.

3) *Electrical Methods.* The electrical conductivity of glass is due almost entirely to the migrating alkali ions. In the surface of glass we have, in addition to alkali, a certain amount of hydrogen ions which participate in conducting an electric current. As a result, the electric conductivity of a glass surface depends not only on its bulk composition but on the alkali content of the surface layer (previous treatment) and on the humidity of the environment. Electric conductivity measurements can be carried out with great accuracy and they can, therefore, be used advantageously to determine changes in the glass surface. Among the earlier work on the surface conductivity of technical glasses as a function of humidity, the measurements of H. L. Curtis[9] (1914) shall be mentioned. The surface conductivity of glasses having a systematically varied composition has been measured by M. Fulda[10] (1927).

Recently M. Kantzer[11] determined the surface conductivity of a number of industrial glasses. In keeping the temperature constant, he could increase the electric conductivity about 40% by raising the humidity to saturation. In the course of this work, he investigated the surface conductivity as a function of dealkalization and of the method employed for polishing.

The fact that electric conductivity can be measured in vacuo provides a method to follow those changes in the glass surface which are not brought about by outside factors, such as humidity or reaction with carbon dioxide. J. H. Mitchel and H. H. Wills[12] found that even the surface of a pyrex glass, despite its low alkali content, undergoes a change at elevated temperature as a result of alkali ions migrating into the surface layer and increasing the surface conductivity.

At the present time, A. M. Mraz in our laboratory is engaged in a research project where the glass is used as the electrolyte of a concentration cell.

A metal in contact with an electrolyte has a certain measurable tendency to send cations into solution and consequently to assume a negative charge. This tendency decreases as the cation concentration in the electrolyte increases. As a result, an E.M.F. is established between two identical pieces of a metal (copper, for example) both immersed in an electrolyte under conditions where the metal ion concentration around the one piece differs from that around the other. At elevated temperatures (130-200°C) a glass plate can be used as the electrolyte. There will be no E.M.F. between two identical metal foils pressed against the two sides of a glass plate if the two glass surfaces have identical structure. However, a difference in the composition between the two glass surfaces affects the tendency of the metal foils to send ions into the glass and thus produces an E.M.F. In various modifications this phenomenon is being used in our laboratory to study the nature and the reactions of glass surfaces. The voltage produced by a concentration cell is relatively small, so that it is advantageous to build up a "pile" by stacking alternate layers of glass and metal foils (Figure 4a). Figure 4b gives the E.M.F. as a function of the temperature for a stack of three (Curve A) and ten (Curve B) concentration cells in series:

Silver/untreated glass surface/silver stained glass surface/silver

The silver in contact with an untreated glass has a greater tendency to send Ag^+ ions into the electrolyte than the one in contact with the surface having received a previous treatment with silver compounds. As a result, the former assumes a negative and the latter a positive charge. When equilibrium is established at about 200°C., the E.M.F. of the single cell was found to be 0.16 volts.

This experiment can be modified by changing the alkali content of the glass surface, its state of oxidation or by treating the glass with vapors of various oxides and metal halides.

4) *Phase Contrast Microscopy.* During the last few years a new instrument, the Phase Contrast Microscope (also called the Phase-Difference or Phase Microscope) has been developed which will become an indispensable tool in the laboratories of glass technologists. This instrument offers unique possibilities for the study of properties and defects of glass surfaces.

A glass plate whose surface has been dealkalized or exposed to silver compounds so that from a certain area Na_2O has been removed or Na^+ replaced by H^+ or Ag^+ shows minor changes in reflectivity because the refractive index of the treated part differs slightly from that of the untreated part. No difference between the changed

(*Continued on page* 254)

GAS FUEL PLAYS IMPORTANT ROLE IN SAFETY GLASS PRODUCTION

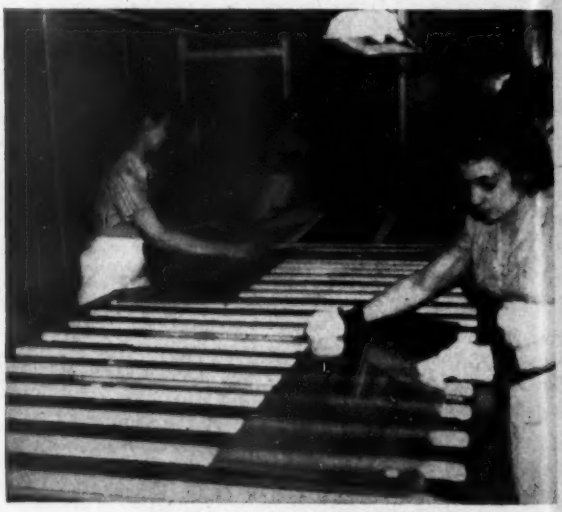
Among the manufacturers supplying parts to the automotive industry in Detroit is the Auto Glass Manufacturing Company, manufacturers of automobile safety glass. This company is unique in that it does not supply glass for new production but produces exclusively for the replacement market—a sort of catering to the crack-up trade which apparently is quite extensive, as their production for this purpose amounts to many thousands of square feet daily.

The production process is comparatively simple as far as physical handling operations are concerned. It consists of merely placing a plastic substance between two sheets of glass and laminating them.

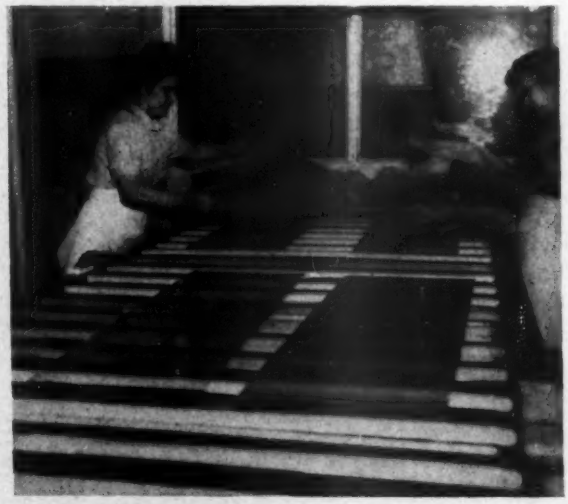
Glass is received from glass manufacturers in stock sizes approximating those for automobile windshields, side and rear windows. The first operation is to place the pieces of 7/64 in. thick polished plate glass on the continuous processing conveyor. The sheets first pass between revolving brushes and a water spray to which a detergent has been added. They are thoroughly washed on both sides, then rinsed by clear water sprays, sent through a set of squeegee rollers, under a dryer where an air blast at 130° F. removes any remaining traces of moisture.

The conveyor carries the sheets of cleaned plate glass into a room which is partitioned off from the rest of the plant where filtered air eliminates any possibility of dust particles being deposited on the glass. Operators place

The sheets of 7/64" polished plate glass start on their journey along the production conveyor at the washing end where a series of sprays and revolving brushes thoroughly clean the glass sheets.



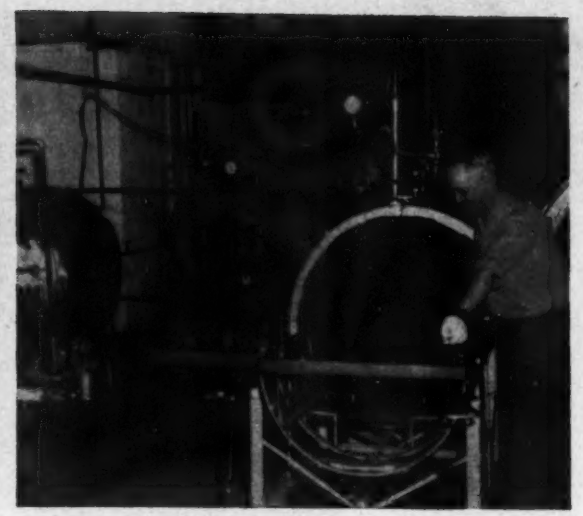
The glass on the bottom to which a piece of plastic has been added is covered with the companion glass on the opposite side of the conveyor making a "sandwich" of two pieces of plate glass with the plastic between.



A piece of plastic .015" thick is placed over one of the cleaned glass sheets.

The next step is the trimming of excess plastic from all around the edges.

At the end of the conveyor, the partially laminated units come from the gas-fired oven. They are then placed on racks and ready for the final heat processing.



Removing a rack of completely laminated pieces of safety glass from a clave where air heated to 300°F. under 125 psi has performed the finishing operation.

sheets of .015 in. plastic, either duPont "Butacite" or Monsanto "Safelex," on one sheet of glass while another operator takes the companion glass and covers the plastic, thus making a glass sandwich with a piece of plastic between. This plastic is pretty much opaque at this stage of the operation. Continuing along on the conveyor, the sets pass through a pre-nipper roll which presses out most of the air bubbles and keeps the "sandwich" in place. Excess plastic around the edges is trimmed off before the units pass between nipper rolls which completely removes any remaining air between the sheets of glass.

The next operation through which the conveyor passes is the first heating operation. This takes place in a direct gas-fired oven having 22 atmospheric burners with 6 tips on each, having a total input of 300,000 Btu's per hour. Here at 180° F. maintained to within very close limits by automatic thermostatic control, the plate glass sheets with the plastic between are partially clarified in the one minute cycle it takes the units to pass through the oven. When the partially laminated "sandwiches" come out of the oven, they arrive at the end of the conveyor. From the time the sheets of plate glass were started on their way at the other end, the traveling time to the discharge end of oven is 3 minutes.

The partially laminated units are taken off the end of the conveyor and placed in racks. These racks of glass "sandwiches" are then run into a clave, where under 125 psi air heated to 300° F. by steam coils inside the clave, they remain for 50 minutes. The steam is supplied by a 40 h.p. gas-fired boiler under automatic control. During the 50 minute heating cycle the two pieces of plate glass are completely laminated, the plastic becomes optically clear, and the unit is completely sealed against any atmospheric changes, water, and will remain so under normal usage in an automobile.

F.T.C. FILES PETITION FOR REHEARING OF S. BUCHSBAUM CASE

The Federal Trade Commission has filed a petition for rehearing with the United States Circuit Court of Appeals in Chicago in the S. Buchsbaum & Company case.

In past proceedings, the Court held that the Commission had erred in ordering the company to discontinue representing its products as "glass" or using the trade name "Elasti-Glass." In its petition for rehearing, the Commission has requested the Court to reconsider its recent decision.

STEUBEN BUYS VERZELINI GOBLET

Steuben Glass of New York has announced the purchase at auction in London of the world famous Verzelini Goblet, the earliest known English drinking glass.

The goblet, eight inches tall, was made by Jacobus Verzelini, glassmaker to Queen Elizabeth. Various hunting scenes and the date 1577 are engraved upon it.

PROFESSOR TURNER ELECTED MEMBER OF FOREIGN ACADEMY

Professor W. E. S. Turner, recently returned to England after spending several months in the United States, has been notified of his election through the decree of the Ministry of Foreign Affairs in Czechoslovakia as a foreign member of the Chemistry and Technology Section of the Masaryk Academy of Work.

CORNING CONSTRUCTION PLANS

Construction of a mixing building designed to service Corning Glass Works' "A" Factory will begin shortly, according to a recent announcement. The new building will be 146 feet high and will have a main superstructure 40 feet in diameter. Raw materials will be delivered by a new railroad siding.

The proposed mixing room will relieve "B" and "C" Factory's Mixing Department of much heavy routine work. It is expected that the new building will be completed early next year.

THE FIGHT AGAINST WASTAGE OF HEAT IN GLASS FURNACES

By IVAN PEYCHES, D. Sc.
Director of Research of the Saint-Gobain Glass Company

TRANSLATED FROM THE BULLETIN DE L'INSTITUT DU VERRE (PARIS) FOR SEPTEMBER, 1946

By F. W. PRESTON

PARTS II AND III

PART II—Savings Arising from Care in Operating

We proceed next to the question of furnace construction and methods of operation. We do not propose to say anything about the increase of efficiency arising from special arrangement of burners, from correct proportioning of the fire-space above the melt, or from other procedures common to industrial furnaces generally, when flame heated. We wish to speak of a problem strictly confined to the glass industry, and not encountered elsewhere.

The process of making glass may be considered, from the point of view of thermal conditions, to be divisible into three distinct stages:

the end of the melting of the batch, at about 1250° C.
the fining process, at about 1450° C.
the cooling-off process, before "working" the glass, at about 1100° C.

Since we are dealing with tank-furnaces, we know that these three stages coexist, at any instant, in different parts of the furnace. Maintaining in a single basin or tank such substantial differences of temperature is possible only because glass is such a poor conductor of heat: its thermal conductivity proper is trifling: its diathermancy, or ability to transmit radiant energy, is correspondingly low: and finally, its high viscosity effectively restrains convection currents. McCauley estimates that the over-all "conductivity" arising from these three methods of heat-exchange is of the order of a watt per centimeter per ° C.

In the big furnaces used for high quality glass (plate glass and window glass), the bath of molten glass is virtually free of obstructions from one end of the tank to the other. The co-existence in this tank of a temperature of 1450° C., where the glass has a density of about 2.14, and a temperature of 1100° C., where it has a density of 2.23, involves the existence of a slow convection movement due to gravity differences: this movement is, at the surface, from the hotter to the colder zone, and in the opposite direction at depth.

These currents, noticed on the surface, were in the old days attributed simply to the pull on the furnace. For twenty years past, however, they have been under close scrutiny, and the principal laws involved have been disentangled. We shall refer to them very shortly.

But first we wish to clarify the underlying causes, and the effects, of these convection currents.

We have just said that the immediate cause is the density difference at the different temperatures demanded by the manufacturing process. To simplify things, we may consider our furnace as comprising simply two zones: the one hot, supplied directly with heat from without, from flames or otherwise: the other comparatively cold, as a rule without an external supply of heat.

This second zone has its own heat losses which, under steady conditions, must be made good. The compensation comes primarily from the sensible* heat, given up as the glass cools. The pull on the tank takes away, as a rule, too little glass, and hence too few heat units: a fifth, or perhaps only a tenth, in a big unobstructed furnace: somewhere around a half in a furnace with a throat. If the pull were the only factor, this part of the tank would have a tendency to chill. In proportion as the difference of temperature between our two zones increases, the convection currents will tend to increase: and so, by this circulation, the compensating heat units are brought in. However, we cannot go very far in this direction, because viscosity increases with reduction of temperature, and this sets a limit to the convection.

In the upshot, an equilibrium is established, which calls for a certain temperature differential and a certain flow of heat. The point of equilibrium depends on the degree of freedom offered to the passage of the current between the two zones.

If the two zones connect only by a narrow passage—a throat or a deep set of floaters—the current is impeded, and a substantial difference of temperature is necessary to attain equilibrium.** Experience, rather than calculation, has determined the appropriate throat dimensions necessary to obtain the required working temperature. If the passage is too narrow, the glass becomes too cold to work: if it is too large, the glass becomes too hot.

If the tank is, on the other hand, clear of obstructions or but slightly restricted, a small difference of temperature will suffice to keep up a supply of heat adequate to balance the heat losses of the second zone.

However, since we need a fall of temperature demanded by the working conditions, we have no recourse but to increase the heat losses of the second zone by some such device as giving it greater dimensions. The currents then become intense, and we frequently measure

*Translator's note: This expression is less common in English than it was in Tyndall's day. It is, in a sense, contrasted with "latent" heat, which is not immediately detectable by a thermometer, whereas "sensible" heat is.

**Translator's note: This particular sentence is not too well expressed, perhaps, in either the French or the English: but it is true if understood in its context, with both preceding and succeeding sentences.

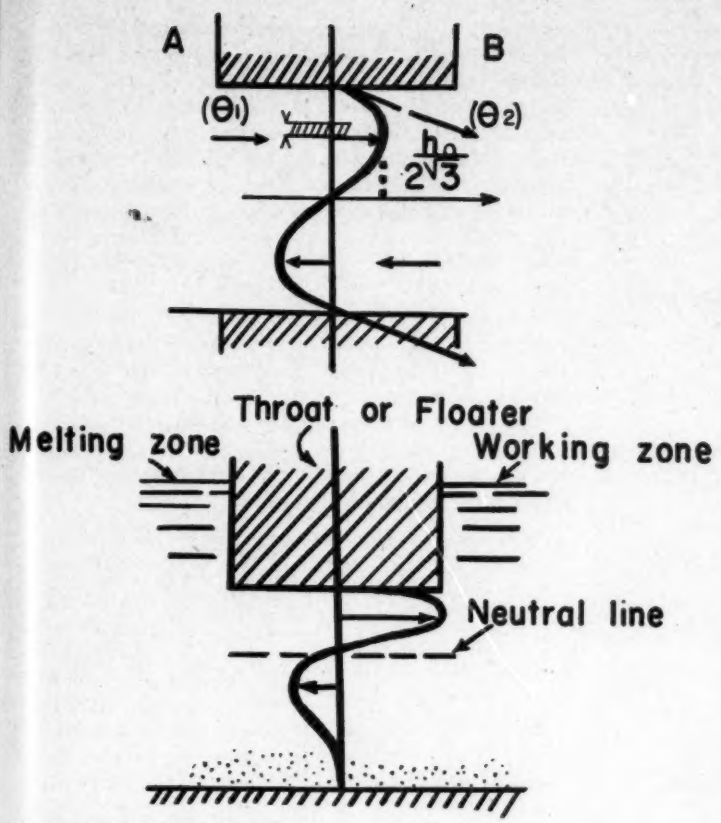


Fig. 8a (top) and 8b (bottom).

surface flows, extending down perhaps to a depth of eight inches or so, and traveling with a speed of thirty or thirty-five feet an hour. These currents involve amounts of glass which may be ten times as great as those called for by the "pull" on the tank. In such a case, nine parts of cold glass return at depth towards the hot end where they pick up a new supply of heat and carry it, and lose it once more, to the cold end. (See Fig. 9)

We shall call this transport of heat the "chain effect".* It takes on the aspect of a devourer of high-class heat units, since they are given to the glass at high potential, and in the ultimate analysis these high potential units are used to compensate for losses sustained in zones of low potential.

The effect upon the efficiency of the furnace is that, whereas a throat-furnace uses about half a pound of coal per pound of glass melted, the wide open furnace uses more than a pound.

Should we then dispense with the second sort of furnace? Here we stumble on a new incompatibility, that between economy on the one hand and quality on the other. These currents, so obnoxious in their transfer of heat, are, on the other hand, so favorable to proper mixing and homogenizing of the glass, that if we are looking for quality, we can get it only in long open furnaces of this sort.

Drawn window glass, and plate glass, which demand a homogeneous melt, are made in furnaces with strong convection currents, and hence with high heat losses and low efficiency. The furnace we have been considering, of 24 tonnes' capacity, if it had to supply a comparable quality of glass, would need an area of 4 meters by 20, if not more.

Throat furnaces, which employ feeble convection currents, produce glass less homogeneous, but adequate for hollow ware, bottles, and pressed ware. Such furnaces are incapable of making good sheet glass.

We must, therefore, once again look more deeply into the phenomena, to see if we can resolve the incompatibility.

The laws of convection have been worked out for simplified conditions and do not pretend to give more than a general outline of phenomena in actual furnaces.

In Figure 8, between two zones A and B, each one at a uniform temperature θ_1 and θ_2 (where θ_1 is the higher), there is established, in a passage of height h_0, length l, and unit width, a double flow of fluid, in the directions indicated in the figure. The velocity curve takes the form of a letter S. The rate of flow is proportional to the cube of the height of the passage way, and directly proportional to the difference of temperature between the two zones.[7] The amount of heat carried from the hot zone to the cold is proportional to the square of the temperature difference and to the fourth power of the height of the passage way.

In the case of the open tank, the friction at the upper surface being suppressed, the velocity curve changes (Fig. 9), but the relations between the temperature differential, the height of the passage (which here becomes simply the depth of the tank) and the velocity or the quantity of heat transferred, remain as before.[8]

In practice, the melt is at uniform temperature neither in the vertical direction nor in the horizontal, in either compartment.

The chief effect of this non-uniformity is to produce variations of viscosity. As a result, the velocity curves we have drawn become deformed, as shown in Figures 8a and 9a.

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*Translator's note: "Effet courroie" in French: not to be confused with "chain reaction" in English. The idea in Dr. Peyches' mind is evidently "courroie sans fin" or "endless belt" effect, implying a perpetual circulation.

7. The complete expression for the velocity curve is:

$$v = Cy\left[y^2 - \left(\frac{h_0}{2}\right)^2\right], \text{ where } C = \frac{\rho_0 g k\,(\theta_1 - \theta_2)}{6\eta l}$$

Here ρ_0 is the density of the glass at 0°C., g is the acceleration due to gravity, k the coefficient of volume expansion, η the mean velocity in the passage way, and y the height of the point under consideration (counted positive or negative on the one side or the other of $h_0/2$).

Maxima occur when $y = \pm \frac{h_0}{2\sqrt{3}}$, and their values are $v_{max} = \pm C \frac{h_0^3}{12\sqrt{3}}$

The quantity of heat carried through per second, in calories, (per unit of width), is $Q = \frac{c\rho_0 g k}{384\eta l}(\theta_1 - \theta_2)^2 h_0^4$,

where c is the specific heat per unit of volume.

8. This time we find

$$Q = \frac{c\rho_0 g k}{200\eta l}(\theta_1 - \theta_2)^2 h_0^4 \text{ (per unit width)}$$

In this expression the width is supposed to be substantial, much larger than the depth, or height, of the passage way, so that friction on the sidewalls may be neglected.

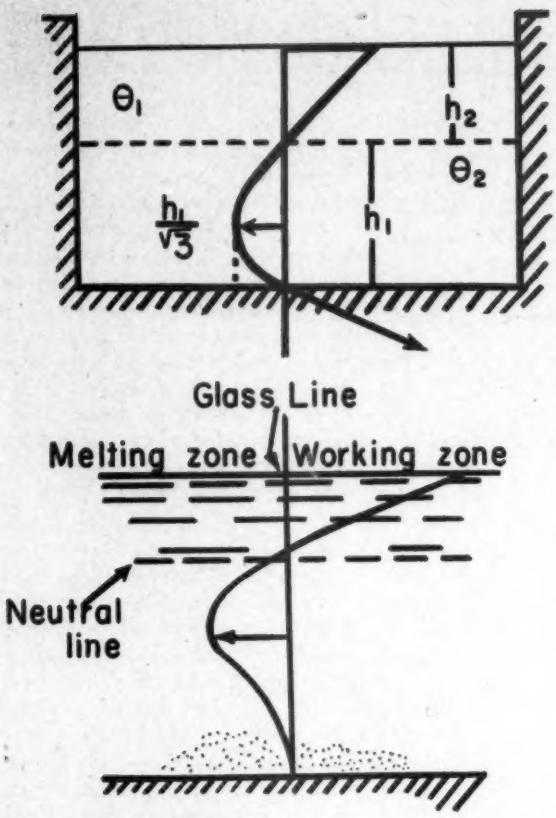

Fig. 9a (top) and 9b (bottom).

The interest of this mathematical representation lies in its drawing our attention to the extreme importance of height. To restrict convection it is much more effectual to work on the height than on the width of the opening. Similarly, the working end is extremely sensitive to variations in the submerged depth of the floaters.

Figures 10a to 10d show the convection currents in direction and velocity, as well as the isotherms as obtained on a model and checked against actual furnaces.

Figure 10a relates to an open tank. We may note the importance of the currents and the zone where the melt is at a temperature suitable for working.

Figure 10b shows a tank with floaters, operating normally.[9]

Figure 10c is a perspective drawing of the convection currents in a bridge-wall tank. It is comprehensible how in this case the glass rising like a spring in the working end will show non-uniformity of temperature along a line perpendicular to the long axis of the furnace, and this makes it difficult to draw a sheet from it.

Anxiety to restrain convection currents as much as possible—and we have seen the part played by height therein—while keeping non-uniformity within bounds, has led us to an arrangement which permits the drawing of a sheet at substantially uniform temperature in the melting end, at such a height that it avoids the aluminous glass near the bottom, and of such a width as to include all the glass that will be used in the drawing operation. Figure 10d shows this arrangement which combines a floater or fixed surface barrier with a step on the bottom of the tank.

Experiment shows that a window glass furnace thus treated may be shortened a good deal without harm to the quality of the glass. There results a very important increase of efficiency.

And so control of the convection currents appears to be a very efficient means of saving heat. We shall see in a few moments how this control, combined with other principles, leads to really economical furnaces.

After these observations which may guide us in modifying the form or the dimensions of the furnace, we cannot very well pass in silence over the conditions under which the glass is worked, after it has been melted. We are dealing here with much more self-evident matters, and we can pass over them very briefly. They concern the manufacturing process proper.

It is certain that the practice of letting the furnace stand idle on Sundays and holidays, however desirable it may appear as a social affair, nonetheless increases the coal consumption per unit output by some 17 to 20 per cent. Everyone knows this: but we are dealing with a matter of a sort into which we cannot enter in detail.

However, the places where waste occurs are too numerous and various to make it possible to get an over-all picture of them. We shall content ourselves with a few examples. Every glass maker must then judge for himself what saving of fuel might be possible, and thus contribute to the general improvement of efficiency.

For instance, the universal practice which consists in using glass to heat up the presses or forming machines will no doubt scandalize the technologist, who knows that the glass cannot give up more than 3 or 4 per cent of the heat that has been required to make it, and is, therefore, the worst possible heating medium. However, the procedure is justified if we consider how easy an operation it is, on the one hand, and what a trifling loss of heat it involves on the other. So an attempt to economize at this point would be once more penny-wise pound-foolish.*

A more important point is the return of skulls** and moils. We had occasion to make some precise calorometric measurements on such skulls in a rolling operation. Glass taken from the furnace at 1100° C. came back in part (about 50 per cent) to the furnace in the form of skulls at an average temperature of 550° C. With a daily production of 24 tonnes, this represents waste heat outside the furnace equivalent to half a tonne of coal.[10]

It is, therefore, a matter of importance to get the skulls back to the furnace as fast as possible. The practice of letting the skulls cool off and sending them back to the furnace as cold cullet, along with the batch, would cost nearly as much as a ton of coal per day.

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9. If the floaters are deeper, there is established the "split regime". A top chain or belt of current breaks against the floater, and is confined to the hot zone: it lies above the main chain or belt and merely sends a few streamers down into it.

*Translator's note: In French: "an economy of candle-ends".

**Translator's note: In French: "fonds de poches", literally "pocket-bottoms". The reference is apparently to the more or less hemispherical layer of glass that chills on the ladle, the unchilled glass being poured out from inside this chilled layer, which is thereafter sent back, still red hot, to the doghouse. Ladling operations are now rare in the States, and the name "skull" may not be generally known, or universally used when the object itself is known.

10. The average value of the specific heat of glass between 550° C. and 1100° C. is 0.25.

For this waste there is already only one remedy—the using of *all* the glass, as is done by feeders, suction machines, drawing machines, and others.

We are now dealing with matters outside the scope of this conference,* since they verge on the organization of the French glass industry, and still more involve the different methods of fabrication, of which the more ticklish ones do not lend themselves to continuous operation.

PART III—Savings Arising from the Rational Use of Thermal Differentials

We finally come to a critical analysis of the physical conditions which limit the melting capacity of a furnace, and hence its efficiency.

We have seen that melting and refining—i.e., the elimination of most of the bubbles arising from the chemical reactions involved in melting, as a result of the lowered viscosity of glass carried to a high temperature—are usually carried on in the same enclosure, the so-called "melting end."

On the surface of the molten glass there floats, in piles or in sheets, the batch we have fed into the tank. This batch forms a screen which prevents the radiation of the roof from reaching the underlying molten glass. We may therefore say that all the energy which is lost by the walls of the tank has been obliged to pass through that part of the surface of the melt which is batch-free.

If we suppose the average temperature of the glass surface to be 1440° C. (1713° K.) and the roof temperature to be 1477° C. (1750° K.)—figures experimentally confirmed—we can calculate the energy thus transmitted from roof to glass, and hence estimate the area of glass surface that must remain free of batch.

Black-body conditions are not very closely approximated in a glass-tank, which is neither "tight" nor at a uniform temperature. Experiment shows that the phenomena are consistent with an assumed coefficient-of-exchange, per unit of receiving surface, of 1/3.

This amounts to saying that we can calculate the energy received, per square meter of glass surface, from the flame space above, by figuring the difference of energies radiated per unit surface of roof and glass for the case of emissivity = 1, and then multiplying by one-third.

Here we find

$\frac{1}{3}\ (536 - 492) = 14.7$ kilowatts per square meter.

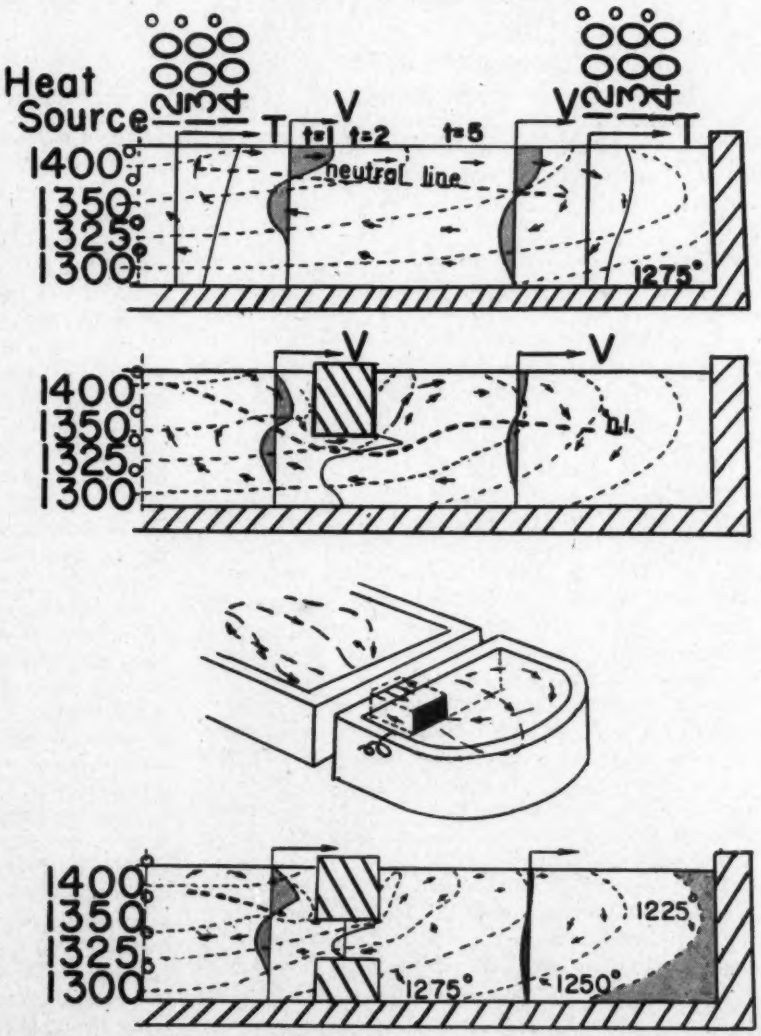
Since we have already calculated the losses from the tank of this type of furnace, and found them to amount to 230 kw., we need, in order to transmit this energy, a batch-free surface of about 15.5 square meters.

The furnace has an area of 24 square meters; so the difference, 8.5 square meters, may be covered with batch. However, the batch piles, introduced as cold material, rise by degrees in temperature, until, in a molten condition, they reach the temperature of the bath.**

We are not here concerned with the question whether melting begins in a surface crust, penetrating by degrees to the colder under-layers of batch. We merely take into account the average temperature of the batch-pile, assuming it homogeneous at any given instant up to the moment of complete fusion.

At the outset, the temperature differential between roof and batch-pile is substantial, and the latter receives a considerable amount of radiation, which diminishes by degrees until it reaches the radiation normal for the melt.

Figure 11 shows how this energy varies during the heating up of the pile, for various roof-temperatures when melting is complete, the situation is the same as if the pile had been at a constant temperature, called its



Top to bottom: 10a, 10b, 10c, 10d.

*Translator's note: See footnote on page 173.

**Translator's note: French "bain", here translated literally, and a little reluctantly, since the shops do not often use the term "bath", to mean the molten glass. But it looks like a perfectly good use of the word.

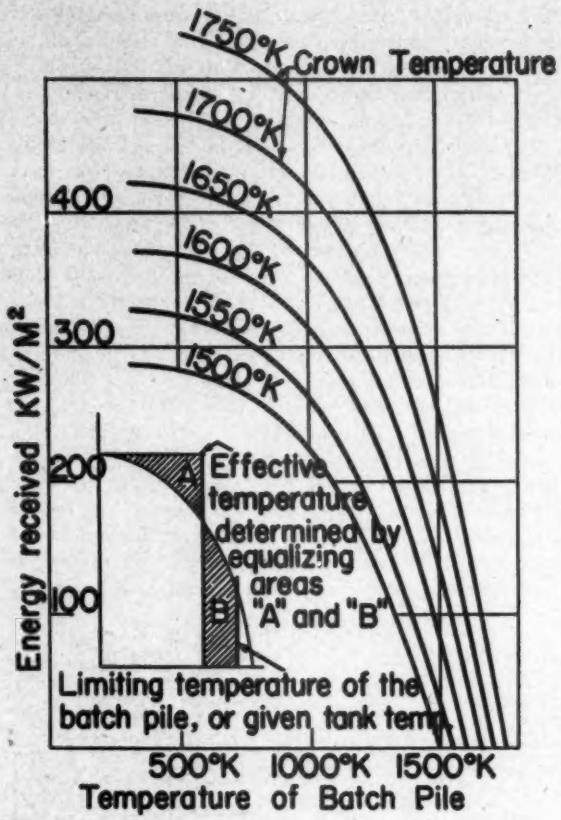


Fig. 11.

"effective temperature," which may be ascertained from the above curves by making the area A equal to the area B.

These (effective) temperatures are listed in Table II.

In the case with which we are concerned, this "effective" batch-pile temperature is 1390° K. (1117° C.). And we calculate the energy taken up per square meter of batch as we did previously for the melt:

$\frac{1}{3}$ (536 — 213) = 108 kw. per square meter.

Since the surface of the batch piles is, as already calculated, around 8.5 square meters, they can take up 920 kw. However, in order to melt 1 kilogram of glass and raise it to 1440° C., there is required 0.7 kilowatt-hours.* The energy absorbed by the batch piles, therefore, permits us to melt 1300 kilograms per hour or about 31 tonnes per day. This represents, under the conditions of temperature that we have assumed, a maximum melting capacity corresponding to 1.3 tonnes per square meter of melting surface. We have indicated, as entirely normal, for a furnace of this sort, a melting capacity of 24 tonnes a day, or say 1 tonne per square meter. In view of the various approximations we have used, not to mention the gymnastics of the calculations, the agreement may be considered entirely satisfactory.

The interest of this calculation resides in the fact that it enables us to understand what it is that limits the melting capacity of a furnace operating by combustion of fuel, when we are given the régime in the flame-space. If we try to feed in more batch, the surface left free

*0.6 kilowatt-hrs. per kilogram of glass, if the latter gives up part of its heat to the cooler glass in the working end. But here we are considering only the melting end.

TABLE II

"Effective" Temperature in °K of batch piles introduced cold and raised to a final temperature T' under a roof radiating energy at temperature T.

T' \ T	1350°K 1077°C	1400°K 1127°C	1450°K 1177°C	1500°K 1227°C	1550°K 1277°C	1600°K 1327°C	1650°K 1377°C	1700°K 1427°C	1750°K 1477°C
1250°K 977°C	1060°	1090°	1115°	1130°	1145°	1160°	1170°	1175°	1175°
1300°K 1027°C	1070°	1105°	1135°	1160°	1180°	1195°	1205°	1210°	1210°
1350°K 1077°C	1075°	1115°	1150°	1180°	1205°	1220°	1230°	1240°	1245°
1400°K 1127°C	1075°	1115°	1155°	1185°	1215°	1235°	1250°	1265°	1275°
1450°K 1177°C	1075°	1120°	1160°	1195°	1230°	1250°	1275°	1290°	1305°
1500°K 1227°C	1080°	1120°	1160°	1200°	1240°	1265°	1290°	1310°	1330°
1550°K 1277°C	1080°	1125°	1165°	1205°	1250°	1280°	1305°	1330°	1350°
1600°K 1327°C	1080°	1125°	1165°	1210°	1255°	1285°	1315°	1340°	1370°
1650°K 1377°C	1080°	1125°	1170°	1215°	1260°	1285°	1320°	1345°	1385°
1700°K 1427°C	1085°	1130°	1175°	1215°	1260°	1290°	1325°	1355°	1390°
1750°K 1477°C	1085°	1130°	1175°	1215°	1265°	1290°	1325°	1355°	1295°

of batch piles diminishes, and not enough energy penetrates below the surface. The bath of molten glass, therefore, cools off, until the thermal differential becomes sufficient to permit the necessary energy to pass through the contracted free surface. But the glass being colder, its quality falls off: in particular, the fining is poorly done. Glassworks practice has for long agreed on the admissible rate of melting and on the proportion of surface that may be covered with batch piles, a proportion which is generally reckoned as between one-third and one-quarter of the total melting-end area.

It is, therefore, the energy penetrating the upper surface of the melt that limits the melting capacity and hence the efficiency of the furnace.

If the furnace were fired from below, like a saucepan, this situation would not occur. And some glass men have argued that such would be the ideal furnace. Unfortunately its construction in practice is another matter.

On the other hand, electric heating by the Joule effect (direct conversion of electrical energy into heat) in the mass of glass allows us to attain easily much higher melting rates, of the order of 2 or even 3 tonnes per square meter. The limit is no longer set by the necessity of having at our disposal a sufficient batch-free area of surface so as to let the bubbles escape in the fining process.

Since we know that melting takes place at temperatures as low as 1250° if we are prepared to make glass of poor quality—that is to say, barely melted, and certainly not plained out—with the idea of improving it subsequently, let us see what the thermal conditions then become.

The roof, we will suppose, has remained at the same temperature as before. Take the glass surface-temperature as being 1277° C. (1550° K.). The energy radiated

(*Continued on page 262.*)

THE WORSHIPFUL COMPANY OF GLASS SELLERS OF THE CITY OF LONDON

By L. M. ANGUS-BUTTERWORTH

Foundation of the Glass Sellers Company

The date of formation of the Worshipful Company of Glass Sellers is a little uncertain. There is at least one reference to them in the reign of Elizabeth, but they were not then incorporated. Under Charles I they obtained permission from the Crown to apply for incorporation, and a draft charter was drawn up dated September 2nd, 1635, with a set of bye-laws dated April 27th, 1636. Delay was caused through the unsettled times, culminating a few years later in the Civil War. Finally a Charter of Incorporation was granted by Charles II under the Great Seal on July 25th, 1664.

Ancient Contracts

Among the possessions of which the Glass Sellers Company is rightly proud are deeds of the 17th century. These, like most important documents of the period, are on parchment, consisting of the skins of sheep, goats or other animals.

The earliest of the Glass Sellers Deeds dates back to 1674, and is an agreement between the famous George Ravenscroft of London and the Company. It is recounted in it that Ravenscroft is working a glasshouse in the Strand, London, for the production of fine crystalline beer and wine glasses in imitation of rock crystal.

The Glass Sellers undertake to buy the whole of Ravenscroft's output for three years, while he agrees not to work more than one furnace, with two master workmen and their necessary servitors, unless a majority require him in writing to make more glasses. In the event of increased demand Ravenscroft is to be allowed to build another furnace at Henley-on-Thames. He undertakes to convey the glasses made to a warehouse between London Bridge and Bridewell.

The Ravenscroft deed is renewed in 1677, and as trade is evidently in a satisfactory state the staff is increased to three master workmen with their servitors. Ravenscroft agrees only to supply the Glass Sellers Company, and they undertake to buy all he makes and not to import glasses from "beyond the seas."

An addition to the later deed is a list of prices, covering bottles large and small, and drinking glasses for beer, claret, brandy, sack and sillabub. The name sack was formerly given to any of the various strong white wines from southern Europe, being from *vin sec*, indicating a "dry" wine. Sillabub is not strictly a drink, having been usually a dish made by mixing wine or cider with milk, forming a soft curd.

Ravenscroft contracts to fit stoppers to all the bottles, and handles if required. All the glasses are to have a Raven's head set in them to distinguish them from others made in imitation, being probably one of the first known examples of a trade-mark.

The second Ravenscroft deed was not fated to run its full term, for attached to it is a letter from George Ravenscroft to Richard Banner, then Clerk of the Glass Sellers Company, dated August 30th, 1678, in which he gives six months notice to end the contract of the previous year, with a draft of Banner's letter accepting this on behalf of the Company.

The task now facing the Glass Sellers Company was to find fresh sources of supply before the notice given by Ravenscroft came to an end. In this they were successful within certain limits, being able to make arrangements regarding cheaper types of glass at the end of four months and better kinds of glass at the end of seven months. The agreements were incorporated in two fresh deeds, still preserved by the Company, which we may now examine.

The earlier of the two new deeds is between the Glass Sellers Company and John Bowles and others who are "Masters of several Glasshouses making green glass near the City of London." The deed is dated January 1st, 1679, and in it Bowles and his friends undertake to supply the Glass Sellers with ware that will "afford them as good if not better pennyworths than any others." No doubt this is an indication that they undertake to give as fair value as their forerunner Ravenscroft.

The agreement is to last for seven years, and the Glassmakers undertake always to have ready a sufficient stock of glass bottles and other green glassware at rates and prices that are set out in a schedule to the deed. The Glass Sellers on their part give an undertaking under penalty that they will not dispose of the glasses to any strangers or aliens.

The later deed, dated April 1st, 1679, records that Michael Rackett "doth keep and is Master of a Glasshouse" for making white and green glasses, and, that John Bowles and William Lillington, Citizen and "Upholder" of London, are partners in a glasshouse in Southwark, making similar types of glass. These men enter into an agreement with the Glass Sellers Company, and as in the earlier deed stocks are to be maintained and prices are to be regulated according to a schedule.

Another important deed is dated February 22nd, 1682. By it thirteen members of the Glass Sellers Company enter into an agreement with one Hawly Bishopp regarding a property in the Savoy, lately in the occupation of George Ravenscroft, gentleman, "which is intended by all the parties for the setting up of a Glasshouse or Blowing House therein."

The Glass Sellers say that, because of the great trust and confidence they have in Hawly Bishopp, they agree to put into his hands stock to the value of £650, or £50 from each of them, to be laid out "in the art or mistery of Christaline or flint glass making under the superintendence of the said H. Bishopp." Proper books of account are to be kept, and the income from the Glasshouse is to be divided between the parties.

The last deed of the series, dated September 1st, 1684, is between John Bowles, William Wood of Wapping and other Glass Makers on the one hand, and John Green with various members of the Glass Sellers Com-

pany on the other. The object is to arrange uniform prices between the glass manufacturers. Settlement of all accounts is to take place every fourth month, and the Glass Makers are to allow 3s. in the £1 discount to the Glass Sellers. It is recorded that the Glass Sellers on their part are to confine their purchases to these London makers, and are not to buy bottles from Country Glass Makers.

Taken together these deeds give a valuable insight into the trading conditions of the period. They indicate clearly how the glass trade of the capital was regulated at a time of transition and development. The documents occupy a significant place in the history of glass-making in Britain.

Apprentices

The system of apprenticeship was well developed in the London Guilds. Under it, care was taken that every new entrant to a trade should be well trained, and should prove his ability and competence before being admitted to the higher grades. On the other hand the apprentice gained solid advantages in that the freedom to practise any trade was strictly limited to those who had undergone the proper training.

The Glass Sellers made a bye-law that no freeman of the Company might take more than one apprentice at a time, unless he was the Master, a Warden, an Assistant or a Liveryman, when he was allowed two. Modification of this bye-law took place in 1669. Again in 1784 the Court consented to each freeman binding two apprentices at once, and even a third or fourth subject to the payment of a fine of 40s. each for every such apprentice, for the use of the Company.

It was no easy task to keep order among the apprentices, and stern measures sometimes had to be taken. Thus in the bye-laws of the Glass Sellers we notice that an unruly apprentice, if he should be a drunkard, haunter of taverns, alehouses, bowling alleys, or other lewd or suspected places of evil company, gamester, dicer, or runner away, should be brought to the hall, stripped and whipped by persons appointed for that purpose.

Finance

An early difficulty which the Glass Sellers Company had to face was a demand of the Crown for funds. Charles II was extravagant and constantly in need of money. The methods he adopted to provide for his needs in this respect now appear very high-handed and irregular. He imposed an assessment upon the City of London by way of loan, to be repaid with interest at the rate of 6% per annum. The Lord Mayor ordered the Company to contribute £310 to this, whereupon one member advanced £50, eight other £25 each, and three £20 each, for which Sir Thomas Player the Treasurer, gave his receipt on December 1st, 1664, on behalf of the King. The remarkable thing is that on April 3rd, 1666, the money was repaid with interest. Others were less fortunate in their experience of loans to royalty.

Charity

The Company's Charity was originally on modest lines, as when it was recorded in March 1698, that "there was found in the Poor Box 3s., and the Renter Warden was ordered to put 2s. more to it, and to pay the same to Old Mitton and Mr. Farlow's daughter each 2s. 6d. apiece, which was done."

In June 1704, the widow of William Carter, named in the Charter as the first Master of the Company, applied for relief and received a small sum from the Poor Box. She applied at several subsequent Courts, and was given further grants. It was naturally the concern of the Company to care for the dependants of those who had served it, as in this case. Sometimes the form of service was of a more humble character. Thus on December 20th 1798, the death of the Beadle, John Pollard, was reported and a petition was received from his daughter stating the distress of his family and asking for a contribution towards his funeral expenses, whereupon his salary due at Xmas was paid and the Court gave his family five guineas. The means for these gifts had to be provided, and this entry appears in the Minute Book on June 19th 1800,—"Ordered that at every Court the Renter Warden put One Guinea into the Poor Box."

In time larger funds accumulated, so that more extensive charity became possible. In 1821 a Liveryman named James Hayes bequeathed £200 for distribution among poor Members of the Company at the discretion of the Court of Assistants. This was made the nucleus of a fund which, through the generosity of other members, was increased to about £800 by 1851, and to about £1,500 at the present time.

The Company began to have regular pensioners. Mrs. Blincks, widow of a Beadle who died in 1827 when she was 31 years of age, petitioned for relief and received an annuity for 33 years afterwards. Another pensioner was Mrs. Hopkins, widow of a former Master, whose grant was discontinued because she "got into trouble by excessive indulgence in drink." In March, 1843, she wrote begging to be restored as a Pensioner, and was reinstated on the list after she had signed the "Teetolle pledge."

In December, 1875, John Abbott, who was then Master, transferred to the Company £1,000 of Madras Guaranteed £5 per cent Railway Stock. The interest from this fund provides a scholarship, tenable for four years at either of the Universities of Oxford or Cambridge. In the award of this scholarship the sons of Freemen of the Glass Sellers Company have the preference.

The Beadle and His Duties

In the latter part of the 17th century the Beadle had to discover "any Pedlars or Hawkers who wander up and down to sell glass, and find out where they dwell and where they sell or offer to sell such glasses, in order to their prosecution." To encourage the Beadle in this amateur detective work he received a gratuity for each pedlar traced,—"he was to be allowed 5s. for each pedlar, hawker and petty chapman whom he shall apprehend for crying or exposing glasses or earthenware to sell about the streets." The amount may not appear large now, but the value of money was then very different.

The Beadle was not always reliable. Thus in 1698 Foster Bach, who was then acting, "being very negligent in his Office and trafficking with hawkers and pedlars, instructing them how to evade the law, was dis-

(*Continued on page* 266)

RECENT TRANSLATIONS OF RUSSIAN PAPERS OF INTEREST TO THE GLASS INDUSTRY

The originals of the four following papers, 1) Production of Fourcault Glass in Russia, 2) Mechanical Treatment of Hardened Glass, 3) A Cooled Fourcault Debiteuse, 4) The Primary Flow of Glass in the Fourcault Tank, appeared in the Russian journal of the glass and ceramic industries.

PRODUCTION OF FOURCAULT GLASS IN RUSSIA

The first Fourcault plant in Russia started production in 1926.

The linear rate of drawing for the ordinary window glass was 35 meters/hour (i.e. 115 ft./hr.) in 1929 and rose up to 50-60 meters/hour (164-197 ft./hr.) in 1936. These latter figures seem to be valid also for the present conditions. In addition to the ordinary glass, glasses of 1.5 and of double thickness are manufactured; their rate of drawing is 0.84 and 0.72, resp. of that of ordinary glass. The selling prices of these 3 glass sheets are in the ratio 1:1·15:1·35 per sq. meter.

The yearly output before the war was 75,000,000 square meters (about 800,000,000 sq. feet) of sheet glass of all thickness.

Within the next few years it is hoped to raise the output to 100,000,000 square meters per year, to achieve the drawing speed of above 90 meters/hour (300 ft./hr.) and to reach a yield of 1 metric ton of glass from 1 sq. meter of the melting area of the tank furnace per 24 hours.

The above data are taken from *Stekolnaya i Keramicheskaya Promyshlennost* (Glass and Ceramic Industries) 1946, No. 4/5.

MECHANICAL TREATMENT OF HARDENED GLASS

Armorglass for use in car windows must satisfy rigid optical requirements. Since rapid cooling of the plate during the course of its hardening often causes a superficial welling which distorts the image seen through the plate, a considerable proportion of the plates had to be rejected in Russia.

An invention described by N. O. Abelchuk in *Stekolnaya i Keramicheskaya Promyshlennost* 1946, No. 4/5, p. 12, allows utilization also of second-grade hardened glass and is said to result in goods of higher quality.

The whole process consists of 6 steps, namely (1) preparation of sheet glass, (2) cutting to size, (3) abrasion to a uniform thickness, (4) treatment of the edges, (5) hardening, and (6) grinding and polishing. The last operation, that is grinding and polishing of hardened glass, is the salient feature of the process.

The experimental testing of the possibility and the results of this operation included the following points.

1. It was shown that grinding and polishing of hardened plates on a standard machinery was feasible without complete destruction of the plate. A commercial alumina powder was the abrasive used.

2. The rate of grinding and polishing of hardened plates was equal to that of similar plates before hardening, and the degree of polish achieved was identical in both instances.

3. The effect of grinding on the stress within hardened glass plates was investigated quantitatively. Plates approximately 25 mm. (1 inch) thick and 195 x 195 mm. (about 7.7 in. x 7.7 in.) large were ground down either on one or on both faces, and the birefringence of the plates was measured after removal of subsequent layers of about 4 mm. each. A polarized light beam passed through one of the 195 mm. x 25 mm. faces to the opposite 195 x 25 face, and the birefringence was expressed as the number of orders per cm. of the path (i.e. the total number of orders divided by 19.5). Table I shows the gradual decline of birefringence caused by the gradual thinning of the plate.

TABLE I.

Effect of grinding on the degree of birefringence.

Specimen	Thickness after grinding in mm.	Birefringence (orders/cm.)	Treatment
No. 1	26.5	2.97	Bilateral
	21.3	2.36	grinding
	16.8	1.59	
	12.1	1.02	
	8.95	0.62	
	3.15	0.06	
No. 2	26.7	3.02	Bilateral
	22.0	2.35	grinding
	16.9	1.58	
No. 3	26.3	3.07	Unilateral
	21.5	2.45	grinding
	17.1	1.69	
	12.6	1.08	
	9.15	0.67	
	3.0	0.136	
No. 4	26.4	2.86	Unilateral
	22.0	2.25	grinding
	16.8	1.58	

In all instances the distribution of stress across the thickness of the plate remained symmetric and parabolic, independently of whether the grinding was carried out uni- or bilaterally.

4. Eleven plates of the above mentioned dimensions (195 x 195 x 25 mm.) were broken in static bending. 3 of these plates were first hardened and then polished on both sides, the layer removed on each side being 0.2-0.7 mm. thick. 4 plates were first hardened and then polished on one side, the thickness of the removed layer being 0.35-0.55 mm. 3 plates were hardened and left unpolished. The original birefringence of all these ten

plates was almost identical and varied only between 2.53 and 3.05 orders per cm. The eleventh plate was neither hardened nor polished and had a birefringence of 0.25 order/cm.

The plates were placed on supports kept 17 cm. apart and bent in the middle by means of a piston. If the pressure on the piston in the moment of rupture was p, the cross-sectional area of the piston S, the distance between the support l, the width of the plate b and the thickness of the plate h, then the breaking stress δ was

$$\delta = \frac{2bh^2}{3pSl}$$

S was 100 sq. cm., b about 19.5 cm. and h about 2.5 cm., so that δ was approximately 21 times the pressure p.

TABLE II.

Breaking stress of polished and unpolished hardened plates.

Specimen	*Treatment*	*Breaking stress (kg.wt./sq.cm.)*
No. 1	Bilateral	2160
No. 2	grinding	2010
No. 3		2324
No. 4	Unilateral	1755
No. 5	grinding	1330
No. 6		2180
No. 7		2052
No. 8	unpolished	2360
No. 9		1755
No. 10		2168
No. 11	not hardened	608

Two of the unilaterally polished plates (No. 6 and No. 7 in Table II) were placed on the supports with the polished face down, and the other two with the polished face up.

Table II shows the δ values obtained in kg.wt. per sq.cm.

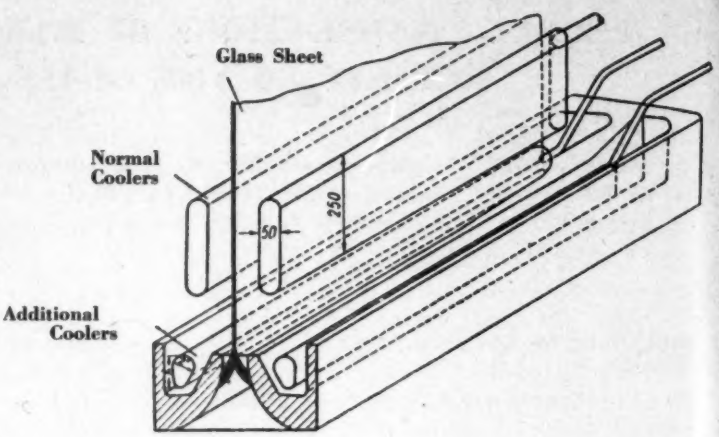
It is seen that polished faces yield breaking stress values which are more consistently high than those shown by hardened but unpolished faces. Other experiments (not reproduced in this abstract) confirmed the above conclusion.

Abelchuk's method was adopted by the Gorki Glass Factory with success. It is not stated in the original article whether other factories adopted it and, if they did not, why.

A COOLED FOURCAULT DEBITEUSE

Fig. 1 illustrates an invention described by L. V. Cherevatenko in *Stekolnaya i Keramicheskaya Promyshlennost*, 1946, No. 3, p. 18.

In the usual Fourcault process the sheet is cooled above the debiteuse. Two coolers of the usual type are marked "Normal Coolers" in the Figure. They are each



250 mm. (about 10 in.) tall and 50 mm. (about 2 in.) wide.

Cherevatenko's debiteuse contains two additional coolers placed in special depressions at both sides of the slit. They are 100 mm. (4 in.) tall and 40 mm. (1.6 in.) broad in the widest place.

According to a factory test the additional cooling allows an increase of the rate of drawing by 20-25 per cent without any reduction in quality.

THE PRIMARY FLOW OF GLASS IN THE FOURCAULT TANK

A Fourcault sheet consists of a mixture of glass materials which spent different times within the tank and, therefore, have slightly different chemical and mechanical properties. This inhomogeneity of sheet glass is an important cause of its defects and breakages. To prove this thesis, M. D. Tamarin carried out some experiments reported in *Stekolnaya i Keramicheskaya Promyshlennost* 1946, No. 4/5, p. 3.

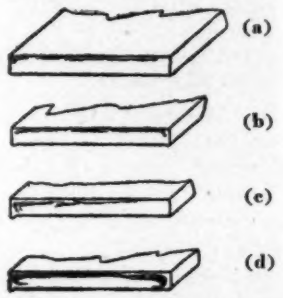


Fig. 1.

The tank used for experiments was 36 m. (118 feet) long. The approximate composition of the glass produced was SiO_2 72, Na_2O 16, CaO 7.7, MgO 2.3, Al_2O_3 1.2, SO_3 0.6 and Fe_2O_3 0.2%. At a definite time some coloring matter (apparently an iron salt) was added to the batch. Later, colored glass mass was seen in the tank. 10-12 hours after this, colored glass emerged from the nearest debiteuse.

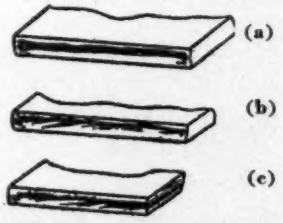


Fig. 2.

Examination of this glass showed that the coloration was not uniform. The main part of the glass was colorless, but near its surface turned toward the center of the channel a thin dark streak was visible; see Fig. 1a, in

(*Continued on page* 268)

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Furnaces

The Cornelius Electric Melting Furnace. Fig. 1. *Patent No.* 2,417,913 is an invention of Anders E. A. S. Cornelius of Stockholm, Sweden, who assigned it to Yngve R. E. Cornelius of Portland, Oregon.

In electric furnaces in which the glass is heated by its resistance to the passage of an electric current,

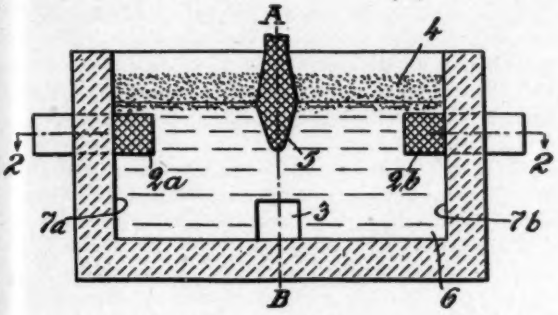


Fig. 1. Cornelius Electric Melting Furnace.

trouble has been encountered due to the fact that the greatest heat is developed adjacent to the electrodes which caused convection currents. Sometimes these currents would carry unmelted batch and seeds in the glass being drawn off at the out-take. The invention overcomes this danger by an arrangement of electrodes which prevents undesired convection currents.

Fig. 1 is a vertical section through a tank having side walls 7a and 7b. There are three lateral electrodes 2a and 2b in line on each side wall. Three central electrodes 5 depend into the glass directly between each pair of lateral electrodes. The current is preferably from a three phase source connected to supply power from phase I and II to the respective lateral electrodes 2a and 2b and phase III to the central electrodes 5. The glass temperatures produced in the bath 6 by this arrangement are such that there is no danger that any of the batch 4 will be carried out through the out-take 3 before it is thoroughly melted.

The following references are of record in the file of this patent: United States Patents 2,122,469, Hitner, July 5, 1938; 2,280,101, Slayter et al., April 21, 1942; 1,594,496, Clark, Aug. 3, 1926; and 2,145,677, Adam, Jr., Jan. 31, 1939.

Glass Compositions

Selenium Ruby Glass, Patent No. 2,418,684. This patent was assigned to E. I. du Pont de Nemours & Company by John M. Youel of Baton Rouge, La. It has been difficult to control the amount of selenium in ruby glass as this material is volatile at melting temperatures and a considerable loss occurs. For this reason, the color of the glass is likely to vary.

The inventor has found that the addition of sodium peroxide to the batch produces a glass of uniform color with slight loss of selenium and which may be melted in an open pot or a continuous tank. The percentage of sodium peroxide may run as high as 20 per cent, but between 3 per cent and 6 per cent is recommended.

Numerous test melts have been made and the following table gives eight of these. The color of the glass became better as the sodium peroxide content was increased at the expense of sodium carbonate. Batch No. 8 was the best.

	Batches, Parts by Weight							
	1	2	3	4	5	6	7	8
Sand	105	105	105	105	105	105	105	105
Sodium Carbonate	44	33	22	0	44	33	22	0
Sodium Peroxide	0	8.1	16.2	32.4	0	8.1	16.2	32.4
Zinc Oxide	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
Potassium Carbonate	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Alumina	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Calcium Oxide	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Bone Ash	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Aluminum	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cadmium Sulfide	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Cadmium Sulfoselenide	4.2	4.2	4.2	4.2	8.4	8.4	8.4	8.4

The batches were heated to 2200 to 2300° F. in crucibles in an enclosed furnace with a soft reducing flame.

The following references are of record in the file of this patent: United States Patents 2,230,199, Dobrovalny, Jan. 28, 1941 and 1,488,914, Gelstharp, April 1, 1924.

Corning Alabaster Glass, Patent No. 2,417,898. This patent was assigned to Corning Glass Works by William H. Armistead. The patent relates to glass for illuminating purposes such as lamp globes and shades. Before the invention, alabaster glass was composed of tight diffusing particles, such as fluorides, sulfates, chlorides, etc. Such compositions were difficult to reproduce exactly. This invention provides an alabaster glass having non-volatile light diffusing particles and which can be reproduced with certainty.

The new glass comprises 30 to 60 per cent PbO, at least 18 per cent Al_2O_3, at least 5 per cent B_2O_3 and at least 10 per cent SiO_2. When this composition is melted, minute crystals are formed which are believed to be $3\,Al_2O_3$-$1\,B_2O_3$. It is thought that this is what gives the glass its highly desirable value.

The following table gives seven examples of the new glass composition in per cent by weight as calculated from the batches:

	1	2	3	4	5	6	7
SiO_2	30	20	15	30	25	30	20
Al_2O_3	20	20	25	20	25	25	20
B_2O_3	5	10	10	10	10	10	20
PbO	45	50	50	40	40	35	40
Translucency	(1)	(1)	(2)	(1)	(2)	(2)	(1)

[1] Medium.
[2] Dense.

The following references are of record in the file of this patent: United States Patents 1,529,259, Locke et al.,

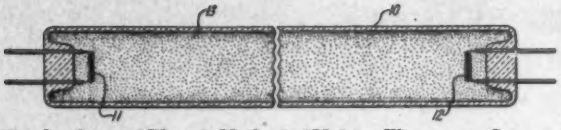


Fig. 2. General Electric Method of Making Fluorescent Lamps.

Mar. 10, 1925 and 2,100,391, Grimm et al., Nov. 30, 1937.

Owens-Corning Fiberglas Corporation offered the following twelve patents for license on reasonable terms to any financially responsible manufacturers. These patents relate to the manufacture of glass fibers and products made from them. The patents are listed with a very brief description in the Official Gazette dated April 8. Copies of the patents may be obtained for 25 cents each from the Commissioner of Patents.

Pat. 1,771,216. Insulating Body of Spun Glass. Patented July 22, 1930. Superimposed layers of glass fibers, the fibers being substantially parallel in the individual layers and the fibers of one layer disposed at an angle to the fibers of adjacent layers, the respective layers being relatively movable.

Pat. 1,875,491. Manufacture of Spun Glass. Patented Sept. 6, 1932. Bushing having parallel spaced apart heating elements disposed within the bushing along opposite sides of the row of orifices.

Pat. 1,923,183. Filament Spinning Apparatus. Patented Aug. 22, 1933. Making crimped or wavy glass fibers by permanently corrugating them or otherwise changing their outline form during their production, and apparatus for carrying out such process.

Pat. 1,950,219. Spun Glass Method and Apparatus. Patented Mar. 6, 1934. Making rope-like masses of glass filaments by drawing a mass of filaments from a body of molten material and dividing the mass of filaments into segregated, rope-like bodies.

Pat. 1,954,732. Method and Apparatus for Making Glass Yarn. Patented Apr. 10, 1934. Glass melting receptacle of metal having a relatively high electrical conductivity and a bridge or bar within the receptacle extending from end to end thereof.

Pat. 2,175,226. Insulating and Weather Resistant Materials. Patented Oct. 10, 1939. Insulated roofing shingles in which a base of impervious weather resistant material has a layer of fibrous glass insulation secured thereto.

Pat. 2,354,765. Camouflage Fabricating Machine. Patented Aug. 1, 1944. Machine for laying cords of fibrous material onto a backing of wire mesh or the like to make camouflage.

Pat. 2,371,458. Camouflage Fabricating Machine. Patented Mar. 13, 1945. Machine including pneumatic means for laying cords of fibrous material onto a backing of wire mesh or the like to make camouflage.

Pat. 2,407,295. Apparatus for Producing Fibrous Glass. Patented Sept. 10, 1946. Apparatus for making glass fibers including a feeder for molten glass having outlet passages that are restricted for a portion of their length.

Pat. 2,407,456. Method of Producing Fibrous Glass. Patented Sept. 10, 1946. Method of making glass fibers in which the molten glass is fed to the attenuating zone in streams that are cooled at different rates during their passage through different portions of their paths.

Pat. 2,407,483. Treating Fibrous Glass. Patented Sept. 10, 1946. Treating glass fiber textiles to reduce the diameter of the fibers and make the textiles softer and more flexible.

Pat. 2,411,326. Making Reinforced Slivers. Patented Nov. 19, 1946. Method of and apparatus for forming reinforced textile slivers by collecting glass fibers in a web and passing a continuous reinforcing strand through the collecting zone to cause the fibers of the web to intertangle about the reinforcing strand.

The Owens-Corning Fiberglas Corporation also offers the following two patents for royalty-free licensing upon the payment of a five dollar application fee for each patent. These two patents do not relate to the manufacture of the fibers but cover products made from the fibers.

Pat. 2,403,872. Treatment of Glass Fibers. Patented July 9, 1946. The method of making glass fiber reinforced resinous articles which includes preliminarily sizing a glass fiber fabric with unreacted resin-forming substances and drying the fabric at a temperature insufficient to completely react the substances.

Pat. 2,404,904. Bonding Glass Fabrics to Inorganic Solids. Patented July 30, 1946. Bonding glass fabrics to inorganic bodies such as metal plates by means of superposed layers of vitreous enamels.

Detailed information may be obtained from Carl G. Staelin, Secretary, Owens-Corning Fiberglas Corporation, Toledo 1, Ohio.

Miscellaneous Processes

General Electric Method of Making Fluorescent Lamps. Patent No. 2,418,202 was assigned to General Electric Company by John E. Stanworth of Rugby, England. The inventor has discovered that the materials in the glass in contact with the fluorescent powder acts to decrease the light output in the course of time. The particular material which causes this loss is the soda in the glass. Therefore, he treats the glass so that the surface in contact with the powder is substantially free from soda.

When the tube is made of a soda-silica glass, the soda may be removed from the inside of the tube by annealing the glass while in contact with sulphur dioxide and air and then washing the tube. The tube may be annealed in this way by using an open fired lehr burning a gas containing sulphur. If there is not sufficient sulphur in the gas, it may be added in the form of carbon disulphide, elementary sulphur of the like.

Another method of freeing the surface of the glass from soda is to wash it in one per cent nitric acid for five minutes which forms a surface skin of silica. A glass suitable for this treatment has the following composition in percentages by weight:

Silica (SiO_2)	40
Barium oxide (BaO)	40
Boric oxide (B_2O_3)	5
Alumina (Al_2O_3)	5
Soda (NaO)	10

Fig. 2 shows a section through a fluorescent lamp made according to this invention. The tube 10 has a pair of electrodes 11 and 12. The tube contains a gas,

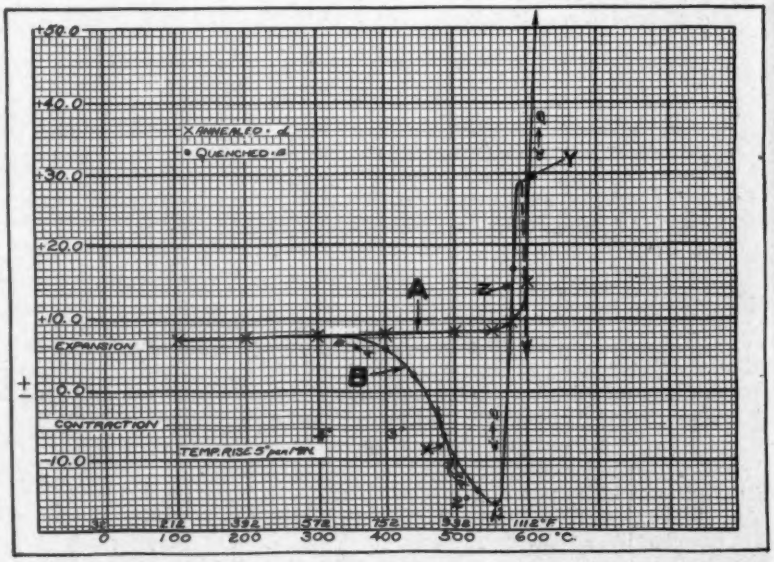


Fig. 3. Method of Annealing Optical Glass.

such as argon, at a pressure of about 1 to 10 mm. and a small quantity of mercury. The layer of fluorescent is indicated at 13. Of course, the invention can be used in other types of lamps.

The following references are of record in the file of this patent: United States Patents 2,030,397, Reynolds, Feb. 11, 1936; 2,030,440, Fritze et al., Feb. 11, 1936; 1,735,302, Slack, Nov. 12, 1929; 2,295,626, Beese, Sept. 15, 1942; 2,238,784, Scott, April 15, 1941; 2,278,742, Scott, Apr. 7, 1942; 2,216,237, Hannum, Oct. 1, 1940; 2,272,992, Hebo, Feb. 10, 1942; 2,303,756, Nordberg & Rumenapp, Dec. 1, 1942; and 2,315,329, Hood & Nordberg, Mar. 30, 1943.

Method of Annealing Optical Glass. Fig. 3. *Patent No.* 2,418,489. This patent is an invention by Edgar D. Tillyer who assigned it to American Optical Company of Southbridge, Mass. It was originally thought that if a test by a polariscope showed strain-free glass, this glass was well annealed. Research has shown that this glass may not be thoroughly annealed but that such glass would change in character in the course of time. The methods employed for determining the proper annealing time have been very slow and expensive and the results were not reliable.

Referring to Fig. 3, the curve A represents the coefficient of expansion of a well compacted glass having a certain arrangement of atoms called the "alpha arrangement." The curve B applies largely in the "beta arrangement" as found in a quenched specimen. The figures at the left of the chart show the actual coefficient of expansion of the glass being tested. The figures at the bottom show the temperatures in centigrade and fahrenheit. A study of the patent, together with the chart, discloses the method of annealing glass by reducing the temperature slowly until the temperature is that of an optimum compacting temperature indicated as being the point of inflection reached in a plotted curve of the coefficient of expansion of a specimen of quenched glass, which optimum temperature is the highest temperature at which all of the glass can change from high temperature or low index form to low temperature or high index form and which temperature is the lowest holding temperature for the particular glass being annealed, holding said temperature for a predetermined time and subsequently cooling.

The following references are of record in the file of this patent: United States Patents 1,585,542, Henry, May 18, 1926; 1,434,268, Tillyer, Oct. 31, 1922; 2,147,418, Bahls, Feb. 14, 1939; 2,148,630, Lillie et al., Feb. 28, 1939; 2,167,482, Hull et al, July 25, 1939; 2,269,597, Mitford, Jan. 13, 1942; 2,285,595, Littleton et al, June 9, 1942; 1,071,331, Mulholland, Aug. 26, 1913; 1,540,264, Henry, June 2, 1925 and 2,062,836, Scott, Dec. 1, 1936; Foreign Patents 431,095, Britain, July 1, 1935.

Eisler Bulb Sealing Machine. Fig. 4, *Patent No.* 2,418,763. This is an invention by Charles Eisler of South Orange, New Jersey, and it is one of a series of his patents relating to the manufacture of electric light bulbs. The patent provides a machine for automatically sealing and molding the neck of a bulb so as to provide recesses to receive spring arms projecting from the screw cap or collar and to thus hold the cap in place.

The machine is of the turret type and the general construction is similar to that shown in other patents

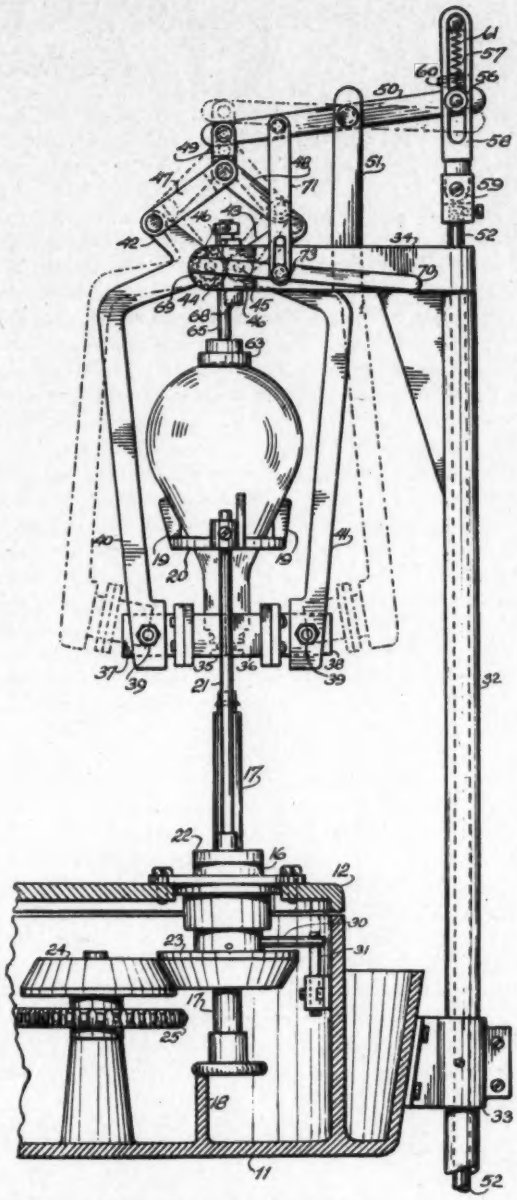


Fig. 4. Eisler Bulb Sealing Machine.

which have issued lately to Mr. Eisler. There are eight working stations as in the commercial Eisler machine, these being a loading station, several heating stations, a sealing station, a molding station (which is the important feature of the patent), an annealing station and finally to the unloading station.

Fig. 4 is a vertical section through the molding station. The molding mechanism is mounted on a standard 33 secured to a base 11. The base and the driving mechanism by which the bulb may be held stationary or rotated at any work station is about the same as shown in Eisler patents which have previously been reviewed. A pair of brackets 34 project from the top of the standard 32 and these carry the mold operating mechanism. The mold comprises halves 35 and 36 adjustably mounted

(*Continued on page* 269)

GI Research Digest

Development of Hard Glasses

This paper by Pavlish and Mockrin (*Journal of the American Ceramic Society*, February 1947), covers a phase of the work which was carried out for the office of Production Research and Development of the War Production Board on the development of glasses of increased hardness for use as instrument bearings. Nearly all of the work reported in this paper was done in the alumina-silicon-boric oxide-calcium oxide system or on glasses derived from this system by substitution of various oxides, chiefly for silica.

Raw batches which gave a yield of about 200 grams of net glass were melted in either zircon or clay crucibles at temperatures of 2750°F or 2850°F. The glasses were crushed and remelted at temperatures of 2700°F to 2750°F for periods of 2 to 4 hours so as to produce homogeneous seed-free glasses. Specimens ¼ inch thick and ½ inch in diameter were formed by pouring and pressing. The pressed specimens were annealed by various procedures so as to be practically strain-free when viewed in a polariscope.

The test specimens were polished to a high finish, the acceptability of which was determined by the general absence of scratches when the sample was viewed under the microscope at 200 magnifications.

The hardness of the specimens obtained in this work was determined in terms of Knoop hardness numbers by means of a Tukon tester for Knoop hardness numbers. In this method, a pyramid-shaped diamond is impressed upon the test specimens under a definite load and for a definite time. The Knoop or indentation number is the ratio of the applied load to the projected area of the indentation before removal of the load. In this work, a load of 500 gm. and a loading time of 20 seconds were used. Diamond-shaped indentations about 100 microns in length were obtained.

The length of the indentation was measured at a magnification of 200 diameters by means of a microscope equipped with a micrometer ocular. Using the length of the diamond and the load, the hardness number was obtained from a table furnished with the instrument. At least five measurements were made on each test specimen, and the average was taken. The usual variations in the hardness numbers for individual specimens ranged from ±10 to ±20 units, about 1.8 to 3.6 per cent. Duplicate specimens prepared from the same melt yielded average values which agreed closely, an average variation of 1 per cent being obtained.

In general, the results of this work show that the hardness of the alumina-silica-boric oxide-lime glass studied is affected to a considerable degree by only a few of the oxides substituted. This is significant because a large variety of oxides were employed and practically all of the substitutions were for silica in the base glass. The substitution of modifiers for the network former, silica, might be expected to decrease the bond strength of the glass structure with a consequent decrease in the hardness of the glass. The results showed that relatively high amounts of modifiers, such as sodium and barium oxide, could be substituted in the particular glass composition studied with little alteration in the hardness of the glass. This indicates that the Knoop hardness of glass depends to a high degree on factors other than the strength of the glass structure, the most important of which is probably the "packing" in the structure. A low coefficient of expansion, high softening point and high chemical resistivity have been associated with a strong glass structure. A comparison of the relative hardnesses of vitreous silica and soda-lime-silica glass affords a good illustration of the danger of explaining hardness wholly on the strength of the structure as exemplified by a low coefficient of thermal expansion. Although the indentation hardnesses of both are about the same, the coefficient of linear thermal expansion of the soda-lime-silica glass is over 100 times that of vitreous silica.

The hardest glass was obtained by the substitution of beryllia for silica in the base glass. Knoop hardness numbers of 660 and 690 were obtained on glasses containing 6.8 and 6.9 per cent beryllia, respectively. Other oxides which yielded homogeneous glasses having Knoop hardness numbers of 600 or greater contained magnesia, ceria, thoria, nickel oxide or iron oxide. The Knoop hardness of glasses containing the various other materials in the specific amounts used did not differ in hardness to any appreciable extent (average approximately 550). The lowest Knoop hardness number, 380, was obtained with a soda-lead oxide-silica glass.

This paper also contains a literature survey on the hardness of glass, in addition to an excellent bibliography of 99 papers dealing with various phases of this subject.

NORTHWESTERN OHIO SECTION TO HOLD SPRING MEETING

The Annual Spring Meeting of the Northwestern Ohio Section of the American Ceramic Society will be held at Fostoria Country Club, Fostoria, Ohio, on Friday, June 6. Arrangements for the meeting are under the general supervision of Robert Twells of Electric Auto Lite Company.

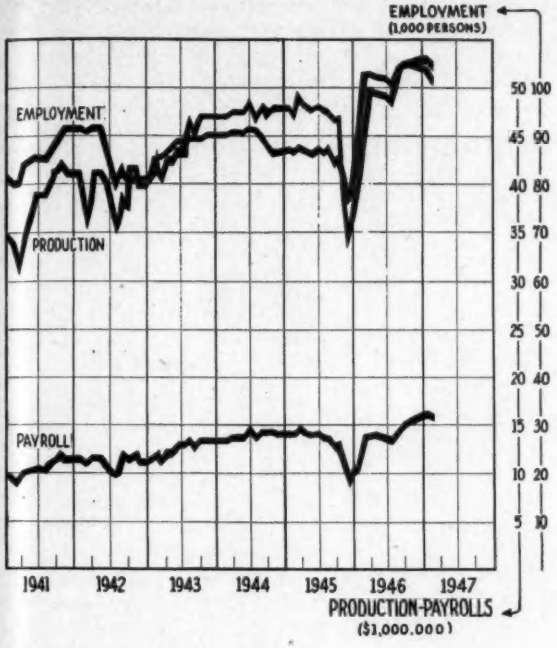
The meeting will begin with golf, cards and plant visits at 1:30 P.M. Several ceramic companies in the area are planning exhibits.

Principal speaker of the evening will be John D. Sullivan, Assistant Director of the Battelle Memorial Institute and President of the American Ceramic Society. His topic will be "Economic and Statistical Considerations of Ceramic Engineering Materials." Charles S. Pearce, General Secretary of the Society, will also be present and will give a short talk.

• The Mississippi Glass Company plans construction of a new building in the near future. Cost of the new building is expected to be $25,000.

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



Activity in the glass industry for the month of February 1947 fell off about 4 per cent from the previous month, according to the Production Index. Production during the month was an estimated $54,500,000 as compared with $57,000,000 reported for January. Production during February 1946 was about $47,600,000, which is about 14 per cent under February this year. Total output for the first two months of 1947 is approximately $111,500,000. During the same period in 1946, activity had reached an estimated $86,500,000.

Employment and payrolls: The number of persons employed in the glass industry during February 1947 fell off about 2 per cent to a total of about 101,500 persons. The January figure was slightly under 104,000. Employment during February 1946 was reported to be an approximate 99,700, which is about 1 per cent below February this year.

Payrolls for February 1947 also dropped in comparison with the previous month. The figure reported was an estimated $15,500,000, or about 4 per cent below the $16,000,000 reported for January. During February 1946, payrolls were $13,000,000, or close to 50 per cent below February this year. During the first two months of 1947, glass manufacturers have paid out an approximate total of $31,500,000 in salaries as compared with $23,600,000 paid out during the first two months of 1946.

Glass container production for the month of March, based on figures released by the Bureau of Census, rose from the February figure of 9,269,161 gross to a total production of 10,640,482 gross. This is an increase over February of about 14 per cent. Total production during the month of March 1946 was reported to be 9,872,373 gross, which is about 7 per cent below March this year. The production total for the first quarter of 1947 is 31,064,620 gross, as compared with 28,703,492 gross for the corresponding period in 1946.

Total shipments for March 1947 were 10,012,450 gross —a drop of about 13 per cent from the 8,859,933 gross shipped during the previous month. During March 1946, shipments were reported to be 9,839,971 gross, or about 1 per cent below March this year. Total shipments for the first quarter of 1947 are 29,523,249 gross, as compared with 28,639,131 gross shipped during the corresponding period in 1946.

Inventories on glass containers at the close of March 1947 were 5,140,116 gross. At the close of February 1947, inventories were 4,167,273 gross and at the close

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production March 1947	*Stocks March 1947*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	3,325,746	2,141,784
	Wide Mouth	3,133,311	1,252,205
Dairy Products		382,801	203,438
Home Canning		201,211	617,537
Beverages, Returnable		851,907	431,454
Beverages, Non-returnable		.....	.....
Beer, Returnable		1,174,261	93,897
Beer, Non-returnable		41,885	6,562
Liquors		1,167,961	248,349
Wines		240,034	105,138
Packers' Tumblers		121,365	39,752
Total		10,640,482	5,140,116

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	March 1947
Narrow Neck Containers	
Foods	918,407
Medicinal & Health Supplies	1,056,756
Chemical, Household, Industrials	568,121
Beverages, Returnable	759,835
Beverages, Non-returnable	.....
Beer, Returnable	1,097,009
Beer, Non-returnable	43,201
Liquors	1,071,697
Wines	220,877
Toiletries & Cosmetics	483,507
Sub-Total (Narrow)	6,219,410
Wide Mouth Containers	
Foods	2,370,333
Dairy Products	356,003
Home Canning	133,161
Medicinal & Health Supplies	277,128
Chemical, Household, Industrials	96,901
Toiletries & Cosmetics	111,351
Packers' Tumblers	125,077
Sub-Total (Wide)	3,469,954
Total Domestic	9,689,364
Export Shipments	323,086
Total Shipments	10,012,450

Remember the name

FERRO CHEMICAL CORP.

FLUORIDES

Now available for immediate shipment

- **SODIUM FLUORIDE 95%**
- **NILE BLUE SODIUM FLUORIDE 95%**
- **AMMONIUM BIFLUORIDE**
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Carload lots available for early delivery

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FERRO CHEMICAL CORP.

Successor to W. B. Lawson, Inc., and Ferro Drier & Chemical Co. (Subsidiary to Ferro Enamel Corporation)

Union Commerce Bldg., Cleveland 14, Ohio

Manufacturers: Driers for Paint and Varnish, Printing Ink, and Allied Industries.

Distributors for: Aluminum Ore Co.; American Potash & Chemical Co.; Darling & Co.; Duquesne Smelting Corp.; Lindsay Light & Chemical Co.; Merck & Co.; Philadelphia Quartz Co.; Stauffer Chemical Corp.; Wyandotte Chemicals Corp.; *and others.*

of March 1946, they were 4,287,338 gross.

Plate glass production, according to the Hughes Statistical Bureau, rose to a total of 22,605,264 sq. ft. for the month of March 1947 from a February 1947 total of 20,267,537 sq. ft. This represents a difference of about 11 per cent. Plate glass production for the month of March 1946 was reported to be 19,292,306 sq. ft., or about 17 per cent below March this year. Total production for the January-March 1947 period is 64,852,415 sq. ft., as compared with 37,497,034 sq. ft. produced during the corresponding period in 1946.

Automatic tumbler production for the month of March 1947 indicated an increase over February of about 29 per cent with a production of 6,272,261 dozens. The February figure was 4,834,577 dozens. During the month of March 1946, production was 7,769,565 dozens. Shipments during March 1947 also rose and were reported to be 5,974,554 dozens, or about 26 per cent over the 4,735,849 dozens shipped during February 1947. Shipments during March 1946 were 7,761,675 dozens. Stocks on hand at the close of March 1947 were 5,575,294 dozens, as compared with 6,478,417 dozens at the close of February 1947 and 5,006,745 dozens at the close of March 1946.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware for the month of March 1947 were 3,213,252 dozens which indicates an approximate 20 per cent increase over the 2,667,998 dozens reported for the month of February 1947. The March 1946 sales figure was 4,153,380 dozens. Total sales for the 12-month period ending March 1947 were 45,076,360 dozens.

PEMCO ELECTS NEW PRESIDENT

An announcement has been made by Pemco Corporation of the election of Richard H. Turk as President of the company. Mr. Turk, who was formerly Executive Vice President, succeeds Karl Turk who will remain Chairman of the Board.

PITTSBURGH PLATE TO MAKE PLANT ADDITION

The construction of a $385,000 addition to the Duplate Department at the Pittsburgh Plate Glass Company's Creighton, Pa., plant has been announced by that company.

Contract for construction of a three-story, brick, steel and concrete structure has been awarded to the Mellon-Stuart Company.

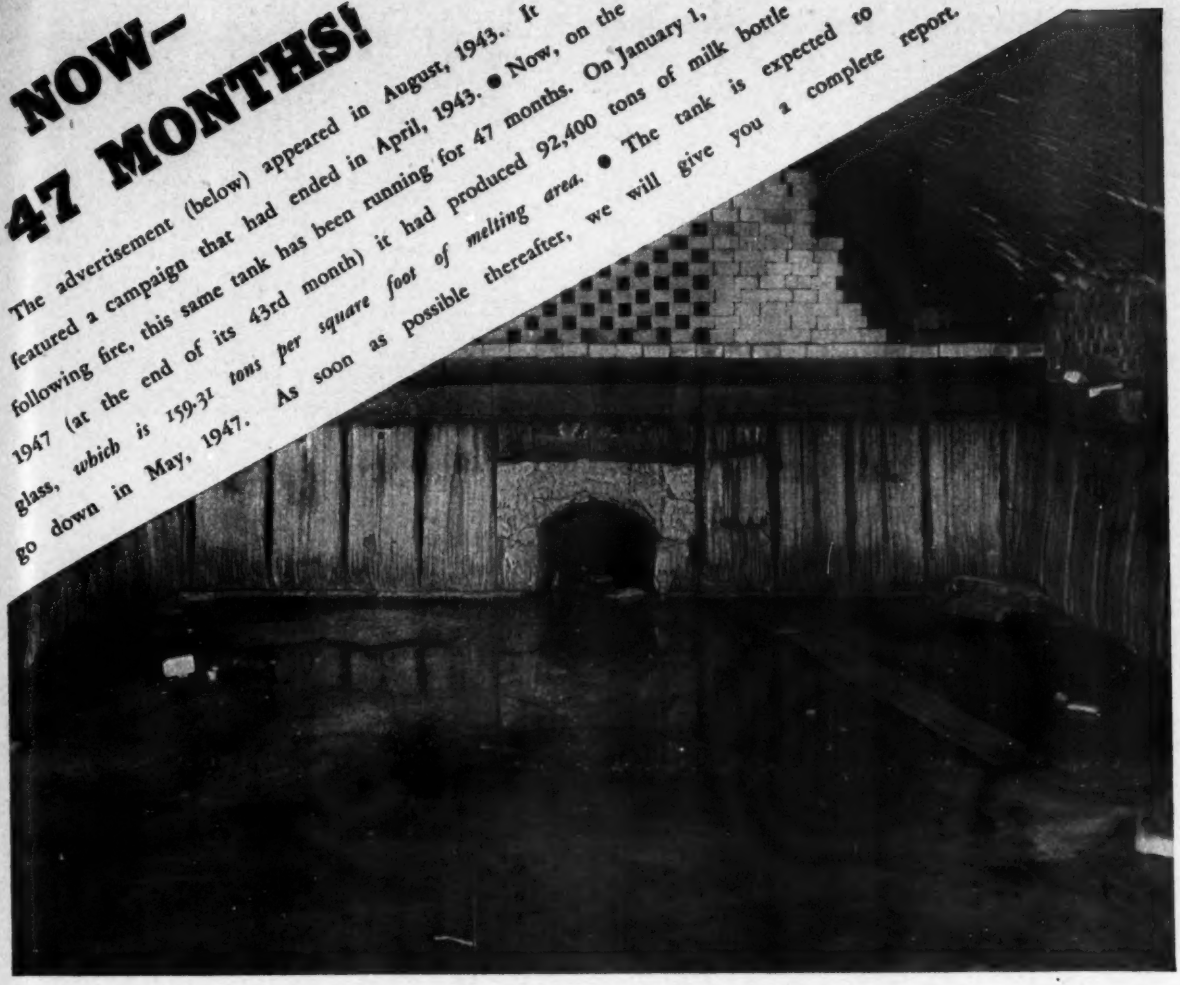
The expansion has been brought about by the increased demand by the automotive industry of Duplate, a laminated safety glass.

It is hoped that the plant addition will be completed within nine to twelve months.

- Minneapolis-Honeywell Regulator Company and its industrial division, Brown Instrument Company, has opened a district office in East Orange, New Jersey.

NOW— 47 MONTHS!

The advertisement (below) appeared in August, 1943. It featured a campaign that had ended in April, 1943. ● Now, on the following fire, this same tank has been running for 47 months. On January 1, 1947 (at the end of its 43rd month) it had produced 92,400 tons of milk bottle glass, *which is 159.31 tons per square foot of melting area.* ● The tank is expected to go down in May, 1947. As soon as possible thereafter, we will give you a complete report.



Floor-level Throat Runs Thirty-one Months!

FOR 31 months, the furnace above operated at high production on milk-bottle glass. It is obvious that in a campaign of this length, with a floor-level throat, no refractory could survive unless it were possessed of extraordinary quality and resistance.

The throat-cover blocks are Corhart* ZED Electrocast. As the photograph shows, the ZED throat not only survived, but apparently had considerable usefulness remaining at the end of the run.

We would be glad to discuss your tank problems with you. *Address:* Corhart Refractories Co., *Incorporated,* 16th and Lee Streets, Louisville, Kentucky.

*Not a product, but a registered trade-mark.

QUALITY ECONOMY ENDURANCE

CORHART ELECTROCAST REFRACTORIES

(*Continued from page* 235)

and the original glass surface can be detected with the microscope in transmitted light despite the fact that a phase difference exists between the light rays which have passed through treated and those which have passed through untreated areas. The difference between both rays cannot be observed directly because our eye is not sensitive to phase differences.

The existence of phase differences has been recognized by Abbe and was utilized for special optical problems by A. E. Conrady and J. Rheinberg at the beginning of this century, but only in 1935 F. Zernike pointed out the possibilities of using phase differences in microscopy. Since this time several scientists, both in Germany and in this country have developed instruments which change a phase difference into an amplitude difference (intensity difference) to which our eyes are very sensitive.

A. H. Bennett, H. Jupnik, H. Osterberg and O. W. Richards[13] in their paper on Phase Microscopy give an excellent description of the historical background and their own contributions in developing a phase microscope. This paper also contains the theory and describes various fields of application.

The characteristic feature of this phase-contrast microscope or phase-difference microscope is to make visible optical path differences. The optical path is defined by $\frac{n.t}{\lambda}$ where n is the index of refraction, t is the thickness of the structure and λ is the wavelength. For a given radiation, optical path differences can be caused by different heights of neighboring parts of a structure (t) or by their having different refractive indices (n). Phase microscopy, therefore, may be used to study surface layers, chemical changes of the surface producing a different refractive index, and finally, surface roughness, such as produced by scratching a glass, polishing operations or contact with a mold.

In the past, microscopy (using dark field or oblique illumination) made it possible to examine structures with rather large optical path differences only for those media where the gradients in optical paths were high. There is no need for pointing out any further the advantage of following with the eye the progress of dealkalization or the development of films on a glass surface. Measuring the thickness of films formed as a result of acid leaching or base exchange reactions may possibly lead to a rapid non-destructive durability test for glass surfaces.

The application of the phase-contrast microscope made it possible for W. Klemm, A. Smekal and W. Loos[14] to prove that under conditions characteristic of mechanical polishing the glass surface actually flows. For this purpose a steel needle was drawn across the optically polished glass surface. Figure 5 gives the picture of the crossing of two tracks made by a steel needle under load of 300g. The needle whose point had a radius of curvature of 55μ produced a scratch which, due to the imperfect surface of the needle point, consisted of 15 single tracks having together an apparent width of 20μ. Actually the width of the scratch is greater (35μ) as can be seen at the place where two needle scratches cross.

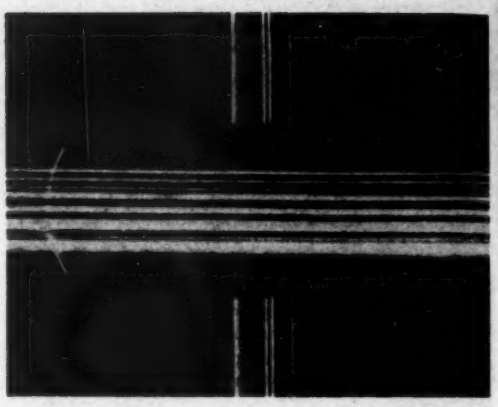


Fig. 5

The picture taken with dark field illumination suggests that the steel needle produced 15 grooves. Examination with the phase microscope proved this impression to be correct. The pressure of the needle was not sufficient to produce cracks but the glass had flown forming channels enclosed by protruding parapets.

This examination established the fact that truly plastic deformation had taken place without fracture. Now it was possible to calculate the volume of the glass which had flown over a distance of one micron. For this purpose the width and the depth of various tracks were measured by means of a microscope interferometer developed by W. Linnik and W. Kinder.[15] One of the deepest of the individual tracks was found to be 0.5μ wide and 0.3μ deep. That means a glass volume of about 1×10^{-13} cm^3 or 0.1μ^3 had flown over the length of one micron. This transport of matter must be considered the basic process of the polishing operation. The details; namely, the smoothing of the glass surface by wiping off the protruding parts and filling up the grooves, were studied near crossings of tracks by means of the phase microscope.

Smekal calculated the energy necessary to cause 1cm^3 of the glass to flow under these conditions and found 10^{11} erg, an energy value which is of the same order as the heat of fusion. E. Madelung[16] using the classical theory of thermal conductivity as a basis calculated that a needle under the pressure of 400g. drawn across a glass surface may produce temperatures of 600°C. over a width of 20μ.

The polishing process consists, therefore, of local heating of the glass making viscous flow possible. The track of a steel needle, diamond point or grains of the polishing medium produces a local rise in the temperature leading to a surface layer which is in a state of compression with an adjacent layer underneath which is under tension.

The explanation of the mechanics of glass polishing is in good agreement with earlier pictures of the polishing of metals. F. P. Bowden and T. P. Hughes,[17] for example, came to similar conclusions for metals by measuring the temperature during the polishing operation in the contact zone. This picture agrees with the observation that a polishing material must not necessarily be hard, but it must have a higher melting point than the material to be polished.

(*Continued on page* 260)

WHY ARE THESE PARTS BLANCHARD-GROUND?

ILLUSTRATED above are ceramic, quartz, glass, carbon, graphite, agate and granite parts—all ground on a Blanchard Surface Grinder—a standard machine tool known to everyone in the mechanical trades.

Blanchard-Grinding was chosen by the manufacturers of these parts because the Blanchard Method gives all three: ACCURACY, FINE FINISH and A HIGH RATE OF REMOVAL OF MATERIAL—all in *one* operation.

Also, the Blanchard Method often eliminates lapping and the resultant possible contamination of the elements of which the part is made.

Graphite pump vanes (shown above) are ground flat and parallel to less than .0001″. The square quartz slices are ground to a thickness of .011″. Agate slices for semi-precious stones can be ground before or after coloring—ground on both sides and the four edges—with extremely fine finish—and at a high rate of production.

Samples of your work ground free of charge and reliable production data are Blanchard Services that will in no way obligate you. Write us today.

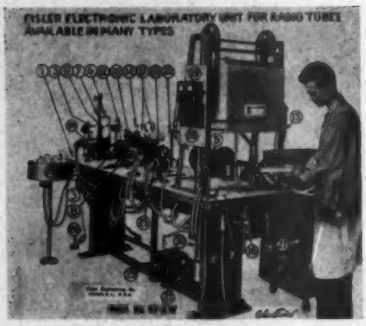
BLANCHARD

The BLANCHARD MACHINE COMPANY

64 STATE STREET, CAMBRIDGE 39, MASS., U. S. A.

NEW EQUIPMENT AND SUPPLIES

EISLER ELECTRONIC LABORATORY UNIT



Eisler Engineering Company, Inc., Newark 3, New Jersey, has developed a new type of electronic laboratory unit capable of performing all operations required for making incandescent lamps, radio and electronic tubes, vacuum switches, photo-electric cells, neon luminous tube-electrodes and similar glass work.

The assembly consists of a sturdy steel fabricated table, covered with a heavy asbestos top upon which the necessary machinery and tools are conveniently located and firmly mounted. The unit is designed to fulfill the requirements for experimental and research laboratories, colleges and vocational institutions teaching glass working methods and for small shops entering this field of production.

Illustrated above are the following features: 1—asbestos covered steel table with piping, valves and necessary connections; 3—adjustable crossfires; 5—glass cutter with one steel and one carborundum disc and ¼ h.p. motor; 6—tipless stem exhaust tube blowing out attachment; 7—flare making chuck; 8—ribbon burner; 9—stem head tipless for small tubes; 10—sealing head for radio tube or lamp; 12—basing head; 13—spark coil; 14—stem head for large stems; 16—exhaust oven electrically heated; 17—tipping torch with gas and air mixer; 18—manifold with four outlets; 19—pinchcocks; 20—soldering fires; 21—½ h.p. driving motor for high vacuum pump; 22—tube or lamp annealer; 23—high vacuum pump, two stage; 24—single burner fire for gas and air with mixer; 25—blow torch; 26—foot treadle for gas saver; 27—No. 10-KW bombarder for radio tubes; 28—electric battery; 29—Pirani type vacuum gauge; 30—metal mercury finishing vacuum pump; and 31—glass rollers.

BRYANT HIGH PRESSURE GAS MIXER

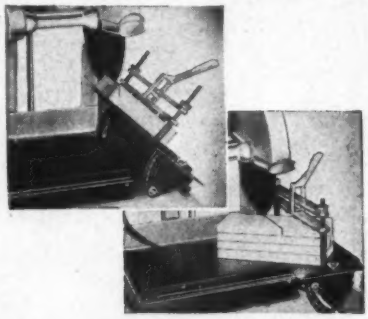
Bryant Heater Company, Industrial Division, Cleveland, Ohio, has announced production of a venturi mixer for high pressure gases known as the "Hijector".

The new unit uses gas under pressures up to 35 pounds to entrain all the air needed for combustion and to deliver the mixture to burners at the highest possible pressure. Overall length of the unit is substantially reduced over conventional designs, according to the announcement, by rearrangement of the elements for ease of servicing. By reversing the usual operation of the air shutter and locating it on the body, the orifice spud is accessible for removal without disconnecting any piping.

Available in pipe sizes ¾″ to 4″, the Hijector is suitable for use with all types of gases, including liquefied petroleum types. An integral cast mounting boss, with drilled and tapped holes, simplifies mounting of auxiliary devices.

ADJUSTABLE MASONRY SAW CLAMP

Clipper Manufacturing Company, 2800 Warwick, Kansas City 8, Missouri, has announced a new "Instant Clamp" adjustable conveyor cart for use in cutting the most intricate shapes and sizes



from regular brick, tile and firebrick. It is designed to handle any thickness of masonry material up to 5″, or width of 12″.

The material to be used is placed on the cart at the desired position and the clamping lever is pulled forward to instantly clamp the material securely in place. The cart is handy for every cutting job and lessens operator fatigue.

Constructed of steel frame, ball bearing wheels and stainless steel adjusting rods with brass fittings, the new clamp is available in two styles: No. 45, for Models "H" and "J" Clipper masonry saws which elevates 45°, and No. 90 for Models "B", "C" and "E" Clippers, a non-elevating design for angles as well as straight cutting.

GLASS DRILLING TOOL

Glass drills said to outlast several dozen ordinary glass drills are now available from several manufacturers, according to a recent announcement made by Carboloy Company, Inc., Detroit, 812 Book Building, Detroit 26, Michigan.

The drills, available in several designs, not only cut down cost of having to continually buy new drills, but also affect material savings in the time required to keep drills sharp, according to the announcement. The greatly increased life and the improved performance of the new glass drills is due to their being tipped with Carboloy cemented carbide. The hardness and wear-resistance of the carbides makes it possible for the sharp tip of the drill to cut as many as 1000 holes before resharpening becomes necessary, it is further stated. This enables an operator to work continually without interruption, drilling holes in any position for every glazing need without the hazard of glass breakage due to dull drills.

TEMPERATURE CONTROL INSTRUMENT

The Claud S. Gordon Company, 3000 S. Wallace Street, Chicago 16, Illinois, has combined in one complete unit all the features of its Xactline Control Unit and the Wheelco Instrument Company's Electronic Principle Capacitrol.

The features which are now brought together in the new Xactline Capacitrol are the anticipating factor which holds temperature tolerances as close as 1/5° F. plus or minus and power "on-off" cycles as short as 3 seconds, positive electrical action, simple adjustment for wide range control requirements, the electronic control principle, instantaneous control action, direct reading indicating scale, separately enclosed measuring instrument and interchangeable unit construction.

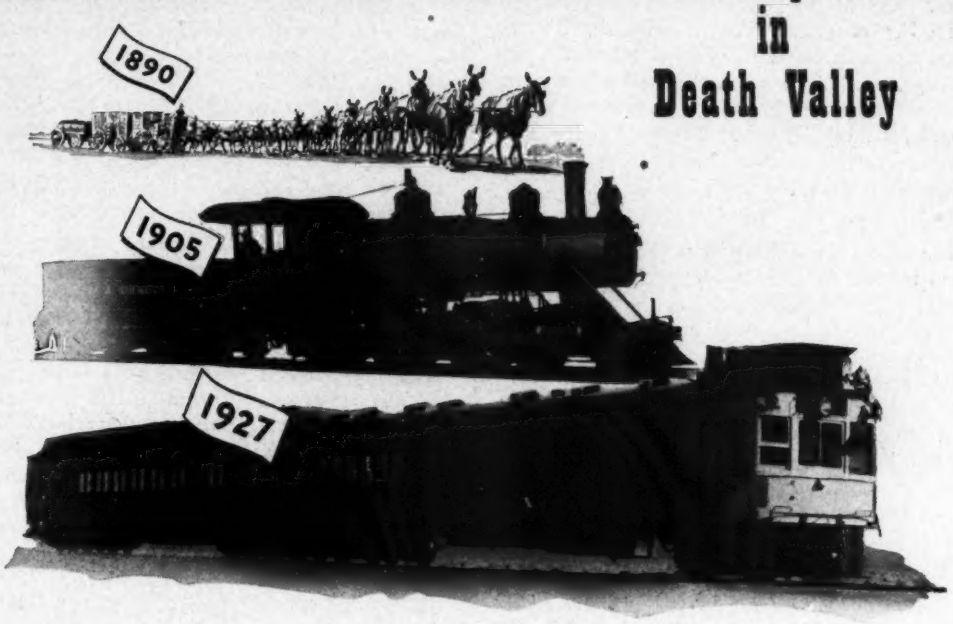
The new Xactline Capacitrol is available in two distinct models for varying requirements. Hook-up for operation is identical to that of the standard model No. 244 Pyrometer Controller (Capacitrol). Flush or surface mounting case plus simple design and compactness make installation a matter of only a few moments' time.

SPEEDOMAX HIGH-SPEED INDICATOR

Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa., has announced the Speedomax Indicator for use where a large number of thermocouple temperatures must be logged.

To read a temperature, the operator flips a key switch marked for the desired thermocouple and the instument's drum scale spins to stop quickly at the correct temperature. The indicator has high sensitivity and accuracy and wide-markings make its scale easy to read. A single instrument handles more than 100 thermocouples and key switches can be color-coded for convenience in identifying points.

Succession of Past Methods of Transportation in Death Valley



THE old 20 Mule Team caravan served admirably in hauling borate ore from the Death Valley mines during the latter part of the 19th century. However, early in the 20th century, the mule teams were compelled to give way to the new Tidewater and Tonopah Railroad built and operated between Ludlow, California on the Santa Fe Railroad and Beatty, Nevada, with Death Valley Junction as the principal intervening point. The entire trackage totalled 169.07 miles.

The operation between Death Valley Junction and Beatty was of comparatively short duration to accommodate the gold rush at Rhyolite in the vicinity of Beatty. Subsequently, the Bullfrog Goldfield Railroad maintained the operation until 1916.

The Tonopah and Tidewater Railroad continued operations between Death Valley Junction and Ludlow, shipping borate ores until 1927, at the time the mines were closed. The Tonopah and Tidewater was then transformed into a gas-electric passenger and baggage service and operated between 1929 and 1940, accommodating the various Death Valley resort facilities.

In the early days the Tonopah and Tidewater trains were operated once a day in both directions and subsequently only two and three trips were provided weekly.

The novel 20 Mule Team caravans and succeeding railroads have vanished with the development of macadam roads throughout Death Valley. Private automobiles, bus services and even the most modern air travel have taken over.

★ ★ ★

QUALITY... Durability, Color and Brilliancy, Strength, Resistance to Thermal and Mechanical Shock are some of the properties which determine the quality of glass. Small quantities of Boric Oxide as a minor constituent in the batch will help to impart these desirable characteristics • *Another good reason why Borax should be used as an essential ingredient in the batch formula* • Our representatives are prepared to discuss the special advantages of B_2O_3 in glass.

PACIFIC COAST BORAX COMPANY

51 MADISON AVENUE, NEW YORK 10, N. Y.

FOR SALE

GLASS PLANT, CHICAGO HEIGHTS, ILLINOIS

By order of the United States District Court for the Northern District of Ohio, Western Division, Owens-Illinois Glass Company offers for sale as a unit all real estate, buildings, machinery, production equipment (not including molds), tanks and furnaces (except experimental machinery and furnaces) located at Chicago Heights, Illinois, and which were a part of the assets acquired by Owens-Illinois Glass Company from Kimble Glass Company on July 1, 1946.

In accordance with the order of the Court such property is offered for sale for cash to any purchaser approved by said Court, subject to prior sale, at the fair market value of said property as a glassware manufacturing plant, as determined by an appraisal made by The Lloyd-Thomas Company, which said appraisal has been duly filed with the Clerk of said Court at Toledo, Ohio., where it may be inspected. Additions and improvements made to the property described above since July 1, 1946, and prior to consummation of sale are not included in the appraised value aforesaid but are offered for sale as a part of the unit for an additional consideration equal to the cost thereof to Owens-Illinois Glass Company.

In connection with the sale of the property and additions and improvements thereto above described, Owens-Illinois Glass Company will assign or cause to be assigned to the purchaser thereof for the consideration hereinafter set forth, all its rights in and to the following machinery and equipment leased from Hartford-Empire Company situate on said premises on July 1, 1946, to-wit:

4—4 head I S machines with feeders, revolving tube drives and motors, and variable speed drives and motors

1—5 head I S machine with same

2—36" x 74' lehrs, gas fired with top vertical discharge, motor driven steel plate exhaust fan, and all regular equipment

The consideration to be paid by the purchaser to Owens-Illinois Glass Company for the assignment of its rights in the leased machinery aforesaid shall be cash in such an amount as will reimburse Owens-Illinois Glass Company for a fair proportion of any and all payments made in connection with said leased machinery by Kimble Glass Company or Owens-Illinois Glass Company which may be considered as costs of installation, advance payments for minimum annual royalties, license fees, parts, insurance and taxes.

In the event of such sale, possession will be delivered not later than six months after the consummation of such sale to a purchaser approved by the said Court.

Address all inquiries to

Owens-Illinois Glass Company
Attention: F. G. Morfoot
P. O. Box 1035, Toledo 1, Ohio

MELLON REPORTS ON 1946-1947 ACTIVITIES

Mellon Institute has prepared a review based on the contents of the Thirty-Fourth Annual Report of the Director, E. R. Weidlein, to the trustees of the institution for the fiscal year ended February 28, 1947.

So as to prepare for the expansion of its activities and services and for new postwar undertakings, the report relates that the institute is strengthening as much as possible its research staff by acquiring specialists and also its facilities by providing more laboratories and by improving its equipment. The Institute has felt the impact of the decreased availability of manpower in recent years because of the war. It has also lost many able scientists since 1942 who have been attracted to avenues of advancement in education and industry.

The professional and social structure of the whole Institute group — the executive, research, and servicing staffs—is given substance by the Robert Kennedy Duncan Club, the organization of the members that keeps alive the name and spirit of the first director. Especially evident throughout the institution is the work of the servicing staff numbering 180. The Institute's department of research in pure chemistry has 3 women and 6 men who rank as fellows, and 2 assistants. There are 5 fellows (one of them a woman) and 1 associate in the department of research in chemical physics. During 1946-47 the Institute's applied science research staff has consisted of 295 fellows (advisory, administrative, senior, industrial, and junior) and their 280 aids (research associates and assistants, laboratorians, and technicians), 34 more fellows and 16 more aids than in the preceding year. Of this personnel 15 women have the grade of fellow and 114 are aids.

These applied science fellows and their aids have been employed on the 80 industrial fellowships in operation during the year—30 individual fellowships and 50 multiple fellowships. Of these fellowships 6 have been proceeding 30 years or longer, others at least as follows: 2, 25 years; 9, 15 years; and 19, 10 years. An additional 22 fellowships have completed 5 years of investigation. Requirements as to more personnel and more laboratory space for many continued investigational programs have restricted in 1946-47 the number of fellowships in action.

Among various fellowships, there are two of direct interest to the glass industry. Fellowships on optical glass, which had been on wartime intermission, have resumed their investigational programs. Completed in 1946-47 was the program on structural glass.

Studies being conducted by the American Refractories Institute's multiple fellowship pertain to testing methods to select suitable grades of castable refractories and heat-set refractory mortars for employment in industry.

The Multiple fellowship sustained by Garco Products, Inc., has a program relating to the development and improvement of novel and valuable materials derived from siliceous by-products of the plate glass industry. "Garsand," one resultant of this research, consists principally of microscopically fine particles of glass and silica, bonded by a process that gives hard, dustless granules of approximately the same size as grains of sand. In the glass batch, this material replaces sand and also supplies a considerable portion of the necessary cullet.

2 WAYS

to approach a color problem

. . . reach for the aspirin OR ask Drakenfeld to help

Reaching for the aspirin never did solve a color problem. Maybe that's why so many glass and ceramic manufacturers turn over their "color headaches" to us year after year.

As specialists in producing colors to meet individual requirements, we would like nothing better than the opportunity of helping to solve your color problems. So—make use of Drakenfeld's broad experience and technical skill. Like other manufacturers, you may find our cooperation can help you step up production, minimize rejects, and produce more ware more profitably.

We believe that we can help you in matching or formulating colors that meet your specifications. Drakenfeld performance is backed by many years of color research and by a comprehensive knowledge of all kinds of methods of producing ceramic and glass products that require color. You can bank on the quality of Drakenfeld colors, coloring chemicals and supplies. Let us discuss how Drakenfeld service can aid you. Write today!

DEPENDABLE SERVICE ON: Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Crystal Ices . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Glassmakers' Chemicals . . . Glass Decolorizers . . . Decorating Supplies.

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C.S.R. ***has excellent resistance to***

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High Grade Refractories for Over 50 Years

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SURFACE CHEMISTRY OF GLASS . . .

(*Continued from page* 254)

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WESTINGHOUSE ANNOUNCES ALL-GLASS SPOTLIGHT LAMP

Westinghouse Electric Corporation has announced the development of a new hermetically sealed all-glass aluminized reflector spotlight lamp for motor vehicles and small motor boats.

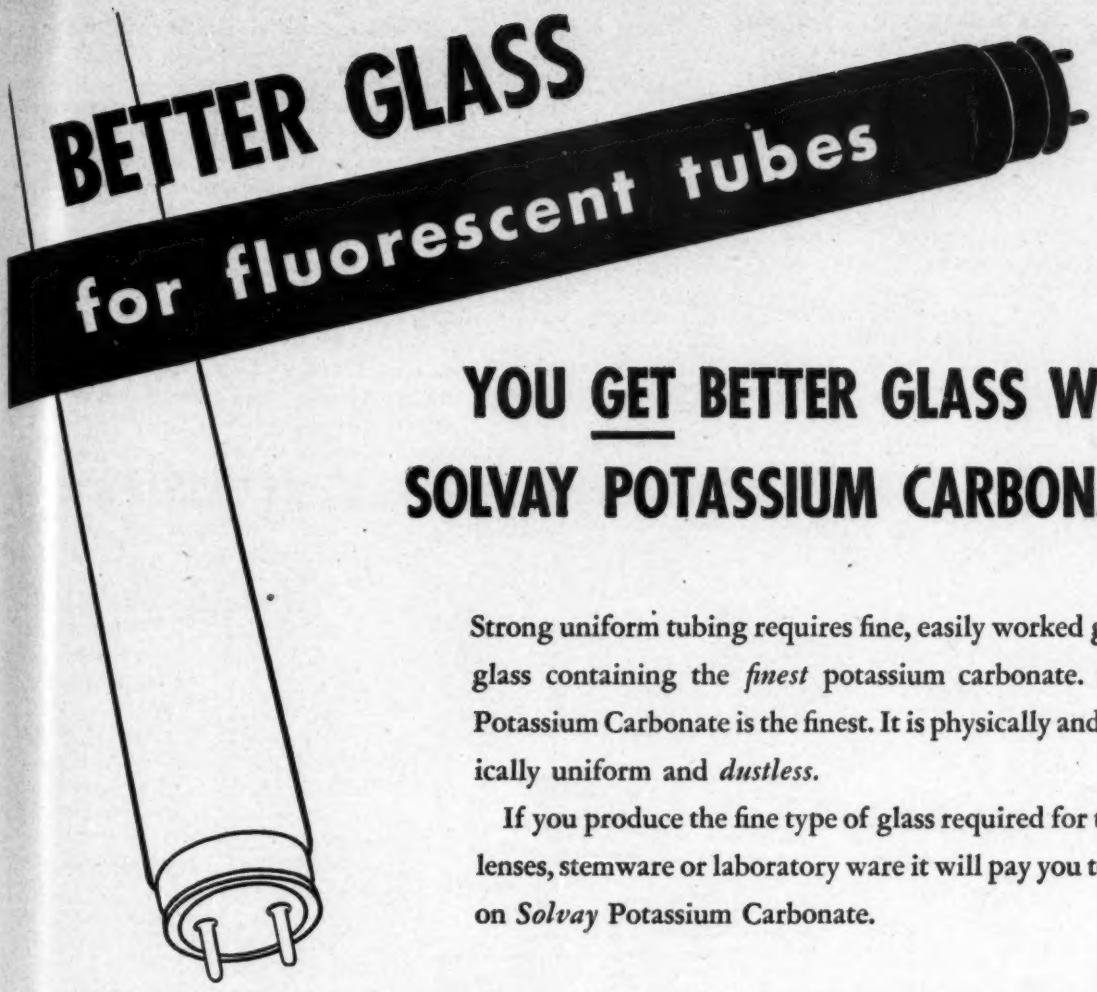
The new lamp, Number 4535, has special design features to enable it to provide a reasonably narrow (6 degrees) beam having high beam candlepower (115,000 cp). The filament is shielded to prevent uncontrolled direct light issuing from the reflector which would create glare due to foreground illumination.

The hermetically sealed reflector of flashed aluminum has an exceptionally high reflection factor (93 per cent) and will not deteriorate when the lamp is exposed to weather or gas fumes. Furthermore, there is virtually no candle power depreciation throughout life.

Although Lamp Number 4535 provides a complete optical package which is renewed at the end of lamp life, it must be placed in a suitable lamp housing with control mechanism for practical automotive and marine use. The lamp is 40 watts, 6-8 volts, PAR-46 bulb, screw terminal base, 100 hours rates average laboratory life and 4 inches maximum overall length.

● Both the Michigan Alkali and J. B. Ford Divisions of Wyandotte Chemicals Corporation now occupy offices in the Henry W. Oliver Building in Pittsburgh, Pa. The Michigan Alkali Division officially opened their space March 15.

BETTER GLASS
for fluorescent tubes



YOU GET BETTER GLASS WITH SOLVAY POTASSIUM CARBONATE

Strong uniform tubing requires fine, easily worked glass—glass containing the *finest* potassium carbonate. Solvay Potassium Carbonate is the finest. It is physically and chemically uniform and *dustless.*

If you produce the fine type of glass required for tubing, lenses, stemware or laboratory ware it will pay you to insist on *Solvay* Potassium Carbonate.

FOR HIGH GRADE GLASS *Buy High Grade*

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EXCLUSIVE!
Dustless Calcined
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(*Continued from page* 242)

to the melt is this time:

⅓ (536 — 332) = 68 kw. per square meter,

or about 4.5 times as much as it was previously.

To make up for the losses from the tank proper, which are now reduced, incidentally, to 200 kw., all we need is a (batch-free) surface of 3 square meters. All the rest of the surface, some 21 square meters, may, theoretically, be covered with batch.

The "effective" temperature of the batch piles is now 1350° K., and the energy they absorb is:

⅓ (536 — 188) = 116 kilowatts per square meter.

The total surface of the piles being around 21 square meters, the energy available for melting them is about 2440 kw., which corresponds to a daily melting capacity of 84 tonnes, or about 2.7 times as much as before.

This increase in melting rate is understandable if we stop to consider the various favorable factors that have intervened: the reduction of heat losses from the tank itself, the increased temperature differential between roof and melt, which permits a reduction in clear surface of the melting end, which in turn involves an increase in the absorbing area of the batch piles, which themselves benefit from the increase of thermal differential.

Figs. 12a and 12b illustrate what we have just said.

The quality of the glass thus half-melted is unsatisfactory, the principal defect being lack of fining. Its temperature must be increased to permit the release of the bubbles. But if this higher temperature coexisted in the same basin as the melting temperature just postulated, convection currents would come into play and render all our thinking faulty.

We need, then, to increase the temperature of the glass in a compartment which does not communicate with the first one, save by an arrangement adapted to cut off convection. The already melted glass will then receive the 150° C. which it lacks. This will call for very little energy, barely 60 watt-hours per kilogram. If the basin is of small size, the losses are trifling, and the efficiency of the whole combination is substantially increased.

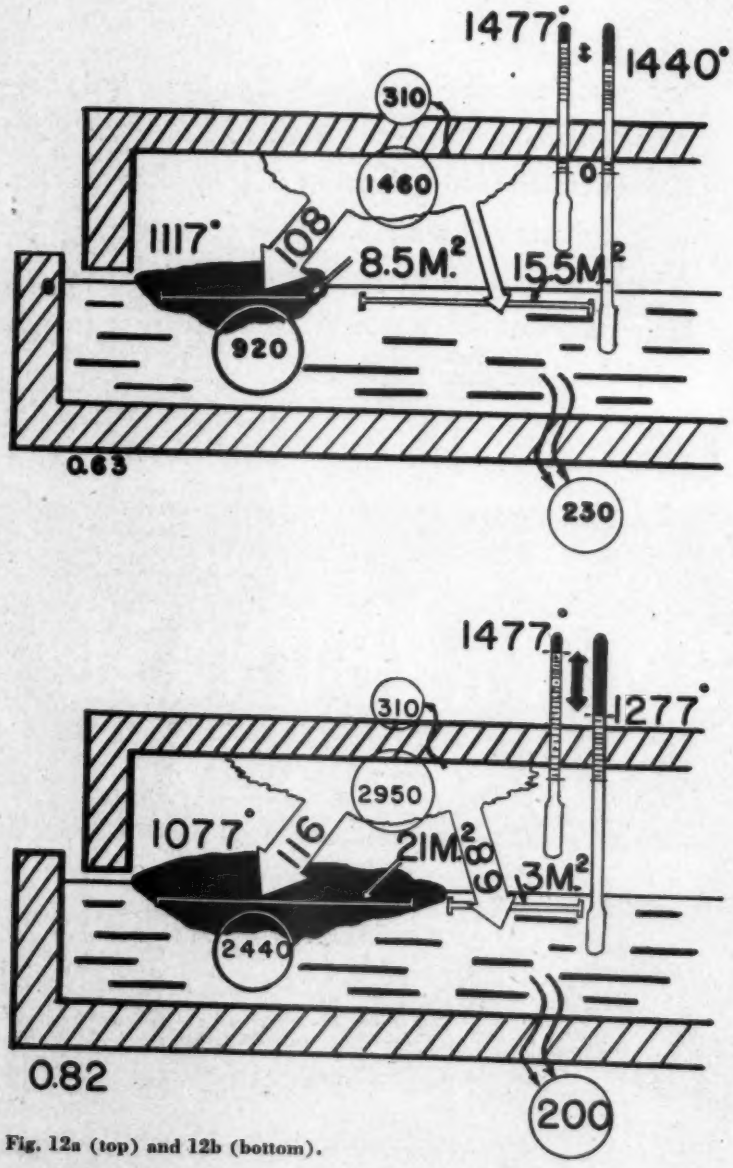

Fig. 12a (top) and 12b (bottom).

It is known that the efficiency of the fire decreases in proportion as it must be used with receivers at high temperature. Flame calories of high thermal potential are expensive calories. On the other hand, calories provided by the Joule effect in the mass of glass are indifferent to the temperature level at which they are used. This strongly suggests that we use electrical energy in this refining chamber, and this is what the Saint-Gobain Company has done for some years past in a number of its furnaces.

The figures which we give below by way of illustration show the attractiveness of this procedure from the point of view of fuel consumption. An orthodox furnace heated by fire and using 0.7 lb. of coal per lb. of glass melted has its production at least doubled when it functions simply as a pre-melting furnace. The coal consumption is reduced to 0.35 lb. per lb. of glass (0.35 kg. per kg. of glass). The electric chamber, adjoining it, takes 0.2 kilowatt-hours per kilogram of glass, losses included.

In other words, 0.2 kilowatt-hours of electricity have replaced 350 grams of coal.

We generally reckon that a good electric generating station, operating on coal, can supply 1 kilowatt-hour from each 600 grams of coal.* As-

*Translator's note: The best present American coal-burning practice is a long way ahead of this figure—around two-thirds of it—which of course would merely strengthen Dr. Peyches' argument.

(*Continued on page* 264)

Smart Decorations for Smart Items with MEYERCORD DECALS

Here is proof . . . real proof that Meyercord Decorative Decals can stimulate sales when used as washable, durable, easily-applied product decoration. These novel lawn tables, called portable "Garden Butlers," are individually decorated as they come off the production line of The Lewis Engineering & Mfg., Co., in Alliance, Ohio. Colorful Meyercord Decals make good products sell better!

GLASS ***proves*** durability and adhesion! Meyercord Decals will withstand repeated washings.

PLASTIC ***proves*** ease of Decal decoration but requires special application treatment.

POTTERY ***proves*** the value of hand-painted effects! Designs applied by cold process after glazing.

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Prove to yourself how you can stimulate product sales with Meyercord Decals. It's the modern, inexpensive way of giving products "alike as peas in a pod" the personal mark demanded by customers. Meyercord Decals can be economically, easily applied at production line speeds on practically any commercial surface, curved or flat. With special types of Decals, even rubber, leather and crinkle finish respond to Meyercord artistry. Hundreds of stock designs are available and exclusive patterns can be produced on request. They're resistant to acids, alcohol, stains and wear. They help sell! For expert decoration suggestions, send sample of product or describe its finish. Address Dept. 20-5.

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ADVERTISE • IDENTIFY • DECORATE . . . WITH MEYERCORD DECALS

THE FIGHT AGAINST WASTAGE OF HEAT IN GLASS FURNACES . . .

(*Continued from page* 262)

suming the most unfavorable situation, that all our electricity comes from coal (and none from hydro power)*, it follows that 120 grams of coal in the electric chamber have replaced 350 grams in the orthodox furnace. The saving of coal is close to ¼ lb. per lb. of glass manufactured.

This saving far outdistances all those we have previously considered. And if we have chosen this example to bring our discussion to a close, it is to show that progress depends more on new concepts, sometimes revolutionary ones, than upon improvements in existing techniques: and also that these new concepts cannot see the light of day or bear their proper fruits save in so far as they are based on solid theoretical foundations, upon accurate measurements; in short, upon all that scientific paraphernalia which is the hall-mark of our century and which is acquiring by degrees a commanding status in all industries, even the most empirical.

I. Peyches

GLOSSARY
(of a few French terms used in Glass-Furnace operation)

This glossary, and my comments thereon, arise out of a recent effort at translating into English an article by Dr. Ivan Peyches (see GLASS INDUSTRY for April). It does not purport to deal with all the technical words occurring in that article, still less to deal with French glass-technological terms in a broad way. I have confined my attention to words that seemed to offer some difficulty, obscurity, or special interest, either because the French is peculiar, or because American usage is a trifle odd.

In this country we do not distinguish clearly between the furnace and the tank. We generally speak of the whole thing as the "tank". The French are more careful. To them the tank (*la cuve*) is the part of the furnace that holds the glass: the gas space above it is *le laboratoire*, though the same word can be used to mean laboratory in our sense. The combination is the furnace (*le four*). The bottom of the tank, which we normally call the bottom-blocks, is *la sole:* the sidewalls of the tank are *la paroi*. This term can apparently be used of the vertical sidewalls of the superstructure (laboratoire), but the term *le piédroit* seems to be preferred. The roof is *le voûte*, literally the vault.

They do not speak of the melting end or working end, but of the zone of fusion and zone of work (*zone de travail*), which again is more logical than our use. The throat is *le spout*. Floaters are *un barrage*, but *barrage* can also be used of a surface obstruction that does not float.

La flottaison (our word flotsam) is "floating wreckage," in this case spreading and collapsing batch piles. *Assise* is a layer or stratum: in brickwork or masonry, a "course." *Assise de flottaison* is accordingly the flux-line course of refractories.

The term *bassin* (basin) can be used in place of *cuve*, apparently interchangeably: and the term *bain* (bath) seems to refer to the contents of the tank, i.e., the melt in its entirety, but can be translated "tank" at times.

The batch is *la composition*, a rather curious use of the word: but a pile of batch is *une motte*. The glass is, of course, *le verre*, and when molten is *le verre fondu*. But in the working end it seems to become *la braise*, literally "the embers." *La braise* however can also be the cooling-off process that occurs in the working end.

The shadow wall is *l'écran*, literally "the screen": but the same word can be used, more literally, of the "screen" produced by the batch as it floats on the glass.

F. W. PRESTON

*Translator's note: Power from coal is apparently more expensive in France than power from water.

EXILED GABLONZ INDUSTRY REVIVED IN U.S. ZONE

Quietly a historical change in industrial geography has taken place under the auspices of the United States: the world famous Jablonec (Gablonz) glass center is being transplanted into certain areas of Bavaria as part of a program rehabilitating skilled workers of German nationality deported from Czechoslovakia. The Gablonz industry comprised hundreds of small manufacturing and home working groups as well as important trading concerns in the fields of glass jewelry, colored glass, bangles and innumerable articles. Several million dollars worth of goods were exported annually to all countries including the United States which was one of the largest customers. According to Dana Adams Smith, correspondent of the New York Times, nearly one hundred and fifty new enterprises employing nearly 12,000 people were started around Bayreuth and Kaufbeuren in Bavaria by former residents of Jablonec (Gablonz). The equally important glass novelty centers in the region of Bor (German Haida) are also reported in a similar stage of development.

While it is true that this revival is primarily a natural step in resettling mass migrants, it must not be overlooked that this production is based on native raw materials and, therefore, will be destined to finance necessary purchases of the US zone in the United States. A strong bid for large United States imports from these new centers of Gablonz type glass in the very near future should not be surprising.

ANCHOR HOCKING STAFF CHANGES

In a recent announcement by William V. Fisher, President of Anchor Hocking Glass Corporation, the resignation of C. Dudley King as Vice President and Director of the company was made known.

At the same time, Mr. Fisher announced five promotions in the company. Paul L. Hershfield has been named Administrative Control Manager. In addition to these duties, he will supervise manufacturing operations.

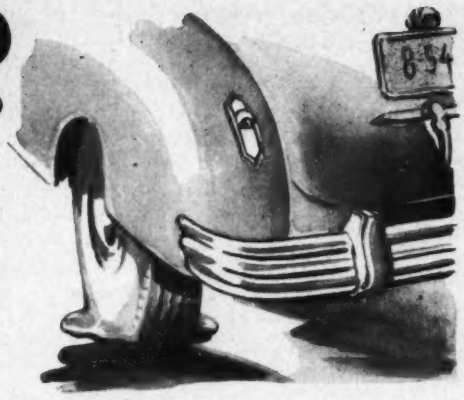
Gordon W. Herrold, former Connellsville, Pa. plant manager, was named General Factories Manager of the packaging division, succeeding Mr. Hershfield. Mr. Herrold has been associated with the company for 20 years.

Appointed to succeed Mr. Herrold is J. M. Fordham who has been with the company since 1929. J. W. Baird succeeds Mr. Fordham as Assistant Plant Manager at the firm's Winchester, Ind. factory and Harry S. McIllvane takes the place of Mr. Baird as Assistant Plant Manager at the Salem, N. J. factory.

Do You Carry a "SPARE"?

Sounds Like a Ridiculous Question, every wise motorist always carries a spare. But!—Are you one of the organizations solely dependent upon one fuel for continuous glass production?

Will forecasted fuel curtailments find you without a "spare"?



TECO DUAL-FIRING

will definitely assure non-stoppage of profitable glass production.

The proper steps taken NOW will insure your future glass out-put against costly interruptions brought on by fuel shortages which threaten to continue to plague the industry.

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TECO DUAL FIRING provides positive reliability with a quick, easy change-over from gas to oil or vice versa. Burners and burner blocks are uncommonly accessible.

High efficiency, flexibility and economy of operation is afforded. Impingement of flame on furnace or tank refractories is reduced to a minimum.

A phone call or letter will place a TECO engineer at your service.

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EASTERN OFFICE 220 E. LEXINGTON ST. BALTIMORE MD. • • • 958 Wall St. TOLEDO, O.

WORSHIPFUL COMPANY OF GLASS SELLERS . . .

(*Continued from page* 244)

charged, whereupon Francis Cornish, Citizen and Framework Knitter, a Messenger of the Chamber of London, was chosen and sworn Beadle." The next man, appointed in the following year, was another unfortunate choice, for there is a record that in January, 1704, "This Court, considering the insolence and divers slights put upon the Company by Richard Kirby the present Beadle, who was chose only during pleasure, resolved to discharge and dismiss him from the said office, and chose John Rudd, a Glass Grinder at Puddledock in his room during the pleasure of this Court, and he was called in and received his charge and was sworn accordingly."

For several years in the middle of the 18th century one Robert Pluckrose was Beadle. One of the Liverymen presented for his use a gown, and a staff in the form of a large bamboo cane. In March, 1747, the Court "ordered that the Beadle attend the Lord Mayor at Guildhall and St. Paul's with the Company's staff, as other Company's Beadles do, and that he have 2s. 6d. each time he attends for his trouble, and that he be allowed a bottle of wine the first time he goes out with the staff, to treat the other Beadles." Evidently the staff had considerable significance as a badge or symbol of office.

Arms of the Company

For centuries the Glass Sellers have used Arms showing a tall goblet in the centre, with a mirror on one side and a jug on the other. A curious feature is that the stem of the drinking glass, twisted in the Venetian manner, sometimes takes the form of a serpent. In the same way the handle and spout of the jug are sometimes formed into serpents. Associated with these objects is the motto "Discordia Frangimur."

These arms, although pleasantly appropriate for the Glass Sellers Company, do not appear to have been drawn up according to the normal laws of heraldry. Perhaps at some future date a more formal grant may be obtained from the College of Arms.

Plate and Furniture of the Company

The Company is the fortunate possessor of some very beautiful things. Some of its treasures are now quite ancient.

In 1687 John Burroughs, who had been Master of the Company a few years earlier, presented a Silver Loving Cup and Cover, having a weight of 40 odd ounces. The reason for the gift was that a Master's dinner had not been held. Nearly a century later, in 1765, an opportunity occurred of matching the Burroughs Cup. In this latter year the Court of Assistants received a legacy of £50 under the will of Frederick Stanton, who had acted as Master in 1731. This sum, then worth very much more than it would be now, was expended upon a cup in which the same elegant lines of the earlier one were followed, and upon two pairs of silver candlesticks. The total cost came to more than the amount of the legacy, but the Executor generously made up the difference.

The most prized possession of the Company is a Master's Chair, presented by Captain Robert Croshaw in

(*Continued on page* 268)

Sodium Sulphate
Sodium Carbonate

for

IMMEDIATE SALE

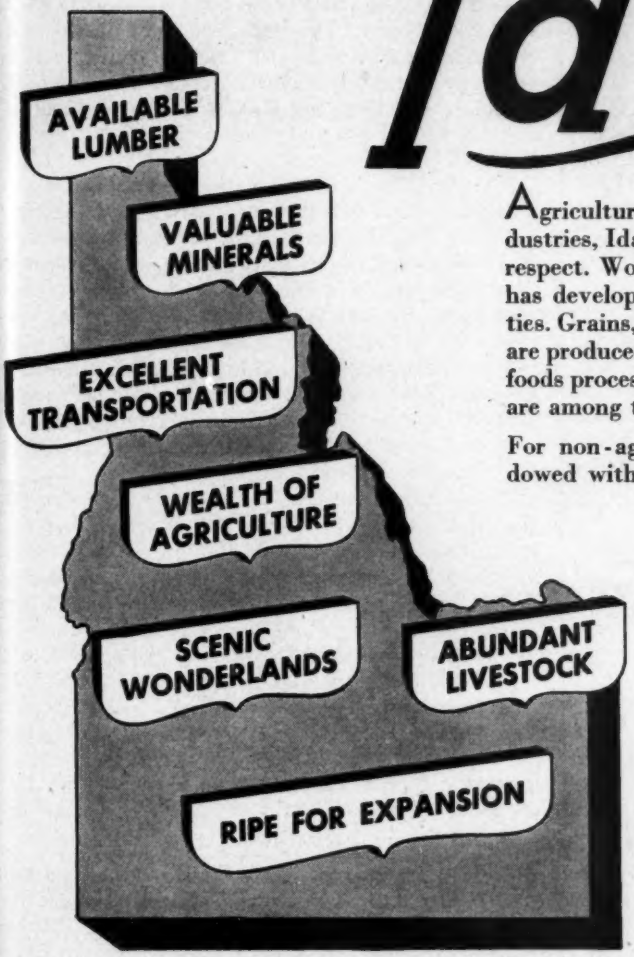
• In natural surface lake deposits located in Wyoming, just off Highway 287, midway between Casper and Rawlins; has never been accurately surveyed; high spot estimates indicate at least 500,000 tons of sulphate and 28,000 tons of carbonate waiting for development; any reasonable offer, preferably on royalty basis, will be considered; inquiries for further detail invited.

Natrona
ALKALI COMPANY
Room 9026 Du Pont Building
WILMINGTON (98), DELAWARE

UNION PACIFIC

TREASURE MAP OF INDUSTRY

Idaho*

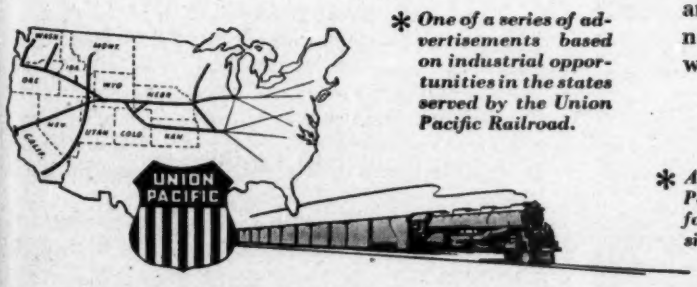


Agriculture being the life-blood of many industries, Idaho is particularly fortunate in that respect. World-famous for the Idaho potato, it has developed many other agricultural activities. Grains, vegetables, fruit... cattle and sheep are produced in abundance. Dehydration, frozen foods processing, dairying, canning and packing are among the state's flourishing industries.

For non-agricultural industries, Idaho is endowed with rich veins of minerals. Numerous manufacturers of stone, clay and glass products have established plants in Idaho. Lumber for building and wood products is available. Unsurpassed rail transportation is provided by Union Pacific.

As a vacation region, Idaho has a wonder-world of its own in Sun Valley . . . year-'round sports center... the world famous primitive area . . . and in the scenic surroundings of Payette Lake.

Idaho is a young thriving state, ripe for further industrial development. It offers good living and working conditions, good schools, splendid cultural advantages... and its energetic citizens assure newcomers of a true western welcome.



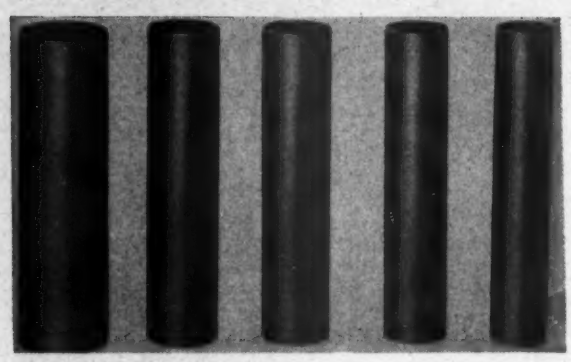
* *One of a series of advertisements based on industrial opportunities in the states served by the Union Pacific Railroad.*

* *Address Industrial Department, Union Pacific Railroad, Omaha 2, Nebraska, for information regarding industrial sites.*

UNION PACIFIC RAILROAD

THE STRATEGIC MIDDLE ROUTE

GUNITE



ROUND BAR STOCK

Gunite can be machined with relative ease, yet has a high density that will take a brilliant polish. Round Bar Stock is available in 18 sizes from ¾" to 5" diameter, all bars 14" long. There is a suitable Gunite alloy for many types of glass-making castings such as Plungers, Ring Sticks, Neck Rings, Guide Rings, Moulds, Blanks, Bottom Plates, etc.

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GUNITE FOUNDRIES
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Then you'll want to investigate Ferro's acid-resisting, applied glass colors—with wide firing range, high gloss and good coverage. Write today for further details.

COLOR DIVISION
FERRO ENAMEL CORPORATION
4150 E. 56TH STREET • CLEVELAND 5, OHIO

WORSHIPFUL COMPANY OF GLASS SELLERS . . .

(*Continued from page* 266)

1704, when he had completed two years in that honourable office. This superb specimen, of Queen Anne style in walnut, has not been altered in any material way since it was made. It appears that in 1859 the chair was re-upholstered in handsome embossed leather, but this gradually became shabby through wear, and in 1925 on expert advice it was re-covered again in beautiful embossed velvet, as this material was appropriate for the original period of manufacture. This Master's Chair was awarded first prize in a City of London exhibition of the properties of all the City Companies. The donor of this chair, Captain Croshaw, was apprenticed to a member of the Company, and made free by service in 1679.

The Poor Box is another extremely attractive piece of workmanship. It was presented in 1690 by John Greene, who had been Master in 1679. It is an exceptionally fine specimen of inlaid work, which has been very carefully preserved. The box has an elegant metal handle and money slot in the lid, which also bears the words "Pray Remember." The sides are ornamented with a pretty floral design, and with the coat of arms of the City of London, including the traditional Tudor dragons that act as supporters. In antique lettering are the words, —"The Gift of Mr. John Green, Senr., a Member of this Company, March the 25th, 1690."

As should be the case the Company possesses some few pieces of glass. Since early in the 18th century the Company has had a Beadle's Staff with a glass head on which is painted the armorial bearings of the Glass Sellers. Some of the glass has been acquired in quite recent times. For example in 1884 Mr. Warden W. G. Taylor gave a piece of stained glass to be added to the Company's collection. In 1893 Dr. Giulio Salviati, a Liveryman of the Company, made a gift of a handsome Venetian ornamental centre piece for the dining table.

RECENT TRANSLATIONS OF RUSSIAN PAPERS . . .

(*Continued from page* 246)

which for the sake of clarity the sheet is shown much thicker than the real sheets. The spread of the dark part increased in subsequent portions of the sheet, see Fig. 1b, 1c, and 1d. On the stage shown on Fig. 1d the colored vein reached across the whole thickness of the sheet near to its borders.

Some 10 hours later the distribution of the dark component was again different, see Fig. 2a, 2b and 2c. The dark band was wider, was situated in the middle of the cross-section of the sheet, and its color intensity was less. The lighter coloration showed that some mixing between the dark and the original glass occurred in the tank. In some instances the band had almost a dendritic appearance, see Fig. 2c.

At a still later stage the wide band disappeared and only thin irregular veins remained. Then they, too, disappeared.

It was observed that, when the dark vein was near one face of the sheet (Fig. 1a) and especially when it was thicker near the border than in the center (Fig. 1d), the sheet was curved across the line of its movement,

the concave side usually containing more colored admixture than the convex side. Obviously, two components of the glass had different physical properties and distorted the sheet during its solidification.

Often the sheet was curved both in the direction of its movement and normally to it.

Curvature of the glass sheet increases its breakage. When the curvature was great, the sheet was broken by the rollers of the Fourcault machine. Less curved sheets survived the rollers but cracked when cut. No cracking occurred when the dark band was in the middle of the sheet, see Fig. 2a. Sheets which survived cutting often were damaged when used for manufacturing triple glass since this process involves pressing glass sheets between plane and parallel plattens.

In the experimental run described above the cause of all these defects was immediately visible. But Tamarin points out that very similar conditions prevail also when no impurity is deliberately added. In every Fourcault furnace there are rapid and slow paths. A glass volume which happened to be on the rapid path reaches the debiteuse hours before another volume which chanced onto a slow path. Because of the different history of these glasses they are different in their chemical composition and physical properties. Because of their high viscosity they do not mix, or mix only very slowly. In this manner an inhomogeneity of the sheet is produced.

INVENTIONS AND INVENTORS . . .

(*Continued from page* 249)

on arms 40 and 41. Each half has two projecting buttons which make four dents in the lower part of the bulb properly positioned to receive projections on four spring arms on the screw collar.

The mold arms 40 and 41 are opened and closed by a toggle 47, 48 actuated by a lever 50 yieldingly connected to a lift rod 52. The lift rod is moved vertically at the proper time to open and close the molds by a cam. The bulb is held down during the molding operation by a disc 63 on the lower end of a rod 65. The rod is moved vertically through connections with a link 71 pivoted on the mold operating lever 50. Various devices are provided for adjustment of the parts and to secure smooth operation.

The following references are of record in the file of this patent: United States Patents 1,617,112, Higgins, Feb. 8, 1927; 2,203,917, Malloy, June 11, 1940; 2,212,842, McGowan, Aug. 27, 1940; 1,338,500, Eisler, Apr. 27, 1920; 1,640,442, De Jong, Aug. 30, 1927; 2,006,231, Malloy et al., June 25, 1935 and 1,832,751, Thomas, Nov. 17, 1931. Foreign Patents 385,537, British, Dec. 29, 1932 and 81,253, Swedish, June 21, 1934.

THATCHER NAMES BRANCH MANAGER

The appointment of B. E. Lowman as Branch Manager of the Thatcher Glass Manufacturing Company's Boston office has recently been announced. Mr. Lowman succeeds J. B. Miller, resigned.

Employed by Thatcher for 31 years, Mr. Lowman has been a salesman in the Philadelphia territory for the past 17 years. Prior to this time, he was night superintendent at the Elmira, New York plant.

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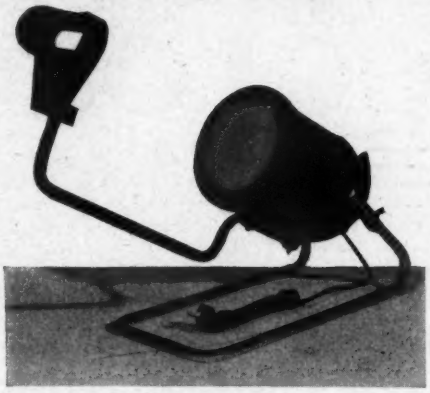

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Lee W. Minton (left) photographed with Felix H. Knight in Buenos Aires during their visit to Argentina with the American Labor Delegation.

THE GLASS INDUSTRY IN THE ARGENTINE

Lee W. Minton, President of the Glass Bottle Blowers Association of the United States and Canada, as a member of the United States Labor Delegation visited Argentina a few months ago for the purpose of studying the condition of Argentina workers' organizations. Mr. Minton, of course, visited some of the Argentine glass plants and has submitted the following brief report of his visit to a typical Argentine glass factory.

"During a visit to Argentina I was privileged to go through one of the larger factories located in Buenos Aires. The construction of its buildings is modern in so far as light and ventilation are concerned. The buildings are of brick and glass construction that give one the impression the industry is far advanced. However, upon entering the plant and analyzing it and its operations, one finds there is no comparison between the American glass industry and that of Argentina. All raw materials necessarily are imported. This certainly creates a problem for management in the allocation of their immediate needs.

"So far as equipment is concerned, the factory is operating two No. 10 Lynch machines. The rest of the factory is employed in hand operation which necessitates a large number of men around each shop. Few women are employed in the factory, and the glass industry itself employs boys of fourteen years of age by special permit. Regular employment is permitted, without permit, of sixteen year old boys. Most deliveries are made by horse and wagon, a not too modern means of transportation. However, due to the extreme lack of fuel during the war years, this sort of delivery was extremely beneficial. There is little or no packing done in paper. Most of it is done in wooden crates packed with straw.

"It was found the etching departments are widely used and their techniques are extremely interesting although it might be added that no new innovations are to be found. The glass factory itself makes all of its own clay pots and other clay products necessarily needed in the manufacture of glass. The minimum rate is on an average of eighty-five centavos.

"In the field of union organization it is extremely interesting to note that the glass workers' union is only

five years old yet they have made great progress in their own particular field. One interesting and important point is that the union is the sole owner of a hospital that gives free medical and surgical aid to its membership. At the present time the union is in the process of constructing a two hundred bed hospital that will be financed mainly by government donation.

"In a competing industry, such as the manufacture of metal cans, the company itself supplies not only complete medical and surgical aid to its employees but also supplies complete dental aid at no cost whatever to the employee. Regardless of the type or character of the illness, this service is given to the employees upon request.

"The glass industry is confronted, of course, with the leisurely attitude of the people generally. Production is nowhere near that of the United States. Saturday afternoons and Sundays are regular holidays. Likewise, the factory is closed completely for two hours each afternoon. This enables the employees to have their so-called siesta or extended lunch periods.

"It is my belief the present government intends to increase production in all industries. There can be no doubt but what the present government intends to industrialize the nation. Primarily, Argentina has been for years strictly an agricultural nation; possibly kept so because of the interest of foreign capital. It was extremely interesting to note the vast difference in the type of ware manufactured in Argentina so far as quality is concerned as compared with American manufacture. Argentina employs highly skilled artisans in the hand departments, some of whom have drifted to Argentina from foreign countries over a period of many years."

INNIS, SPEIDEN ELECTS SECRETARY

W. H. Sheffield, Jr. has been elected as Secretary of Innis, Speiden & Company, it was announced following the annual organization meeting of the Board of Directors. Mr. Sheffield, who is Assistant Treasurer of the company, was also re-elected Director.

All the company Directors were re-elected and W. H. Sheffield continues as President and Director.

PACIFIC INDUSTRIAL CONFERENCES ANNOUNCED

The American Chemical Society has announced that the Pacific Industrial Conferences will be held in the San Francisco Civic Auditorium from October 21 to 25, 1947. The Conferences will run concurrently with the Pacific Chemical Exposition.

The California Section of the American Chemical Society will be host to ten organized groups which have offered to provide the bulk of the program material for the Conferences by conducting one- and two-day conferences on industrial applications of recent scientific developments.

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JOHN ROMIG JOINS CHAMPION LAMP WORKS

John W. Romig, recently resigned from Corning Glass Works, has joined the Champion Lamp Works as Assistant Manager. Mr. Romig's duties will embrace manufacturing, engineering and sales of incandescent and fluorescent lamps.

In his association with Corning, Mr. Romig was General Sales Manager of the technical products division, and had held various posts in the engineering, manufacturing, sales and treasury departments of the company.

CHARLES LA FOLLETTE NAMED DOW CORNING DIRECTOR

Charles D. LaFollette, Vice President and Treasurer of Corning Glass Works, was elected a Director of Dow Corning Corporation at a recent meeting of the Board of Directors.

Mr. LaFollette will fill the unexpired term of Eugene W. Ritter who resigned to take up his duties in Buenos Aires as President of Corning Glass Works of South America.

Mr. LaFollette continues as Treasurer of Dow Corning Corporation, a post he has held since the organization of the company in 1943. He is also a Director of Corning Glass Works, Steuben Glass, Inc., Corning Fibre Box Corporation and Corning Glass Works of Canada Ltd.

• A. J. Fischer has been appointed manager of the Carbide and Cast Alloy Division of the Jessop Steel Company, Washington, Pa., according to a recent announcement. Mr. Fischer joined the company this year.

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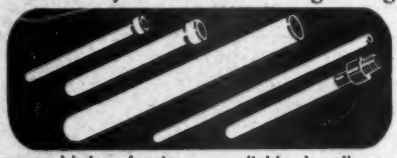

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